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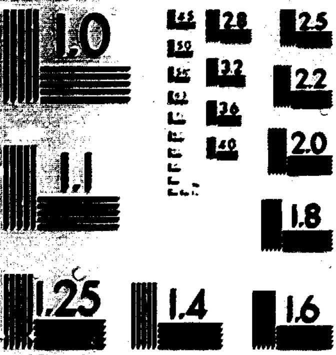

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ENERGY CONSERVATION IN INDUSTRY

DP/EGY/83/001

EGYPT

Technical report: Energy Management Systems *

Prepared for the Government of Egypt
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of F.J. Feltoe,
Expert in Industrial Energy Management

United Nations Industrial Development Organization
Vienna

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EXPLANATORY NOTES

The following abbreviations are used:

ITMS	:	TABBIN INSTITUTE FOR METALLURGICAL STUDIES
IECC	:	INDUSTRIAL ENERGY CONSERVATION CENTRE
M and T	:	MONITORING AND TARGETING SYSTEM OF ENERGY MANAGEMENT
D. En.	:	U.K. DEPARTMENT OF ENERGY
ETSU	:	U.K. ENERGY TECHNOLOGY SUPPORT UNIT - HARWELL

PREFACE

Much of Energy Management, and in particular, Monitoring and Targeting is "a statement of the obvious", but needs no apology because of that:-

It is not high technology!

It is high common sense!

It is not high cost!

It can be, highly profitable!

It is good management!

Energy must be managed and needs a simple but reliable structure to allow this to be done. Monitoring and Targeting provides such a structure.

ABSTRACT.

Project Reference DP/EGY/83/001

This short mission (two weeks including travel etc.) had as its main objective, the introduction of Energy management techniques, based on recent experience in the United Kingdom, to the staff of the Industrial Energy Conservation Centre, attached to the Tabbin Institute for Metallurgical Studies, and to a number of representatives from industry.

The principal feature was the explanation of "Monitoring and Targeting" as a low cost mechanism for improving the management (and therefore cost) of energy, in whole industrial sectors within a reasonably short time-scale.

Because of the background of the author, the Iron and Steel Industry was used as the example, but it was emphasized that "Monitoring and Targeting" applies to all industries and that it concentrates on management rather than on technology or capital investment in new plant.

The principal recommendations are

1) to bring to the attention of senior people in Government and Industry, the fact that a strategy exists for achieving economies in wide areas of industry, at modest cost.

2) to use and modify the expertise being developed in the Tabbin Institute to assist in the introduction of monitoring and targeting into Egyptian industry.

3) to study the information on iron and steel industry energy performance norms, or "standards" presented by the author during the mission, and to prepare similar preliminary information for Egyptian industry in order to assess its relative performance at the present time.

4) to introduce some method of using true energy costs in order to assess management performance and to provide greater incentive for improvement.

INTRODUCTION.

Programme of Mission.

A. Seminar on "Energy Management Techniques in the Iron and Steel Industry"
This was based on the following two papers which form appendices to this report.
"Energy Management in the British Steel Corporation" by F. J. Feltoe.
"Energy Management in the Steel Industry - surmounting the Barriers to Technological Improvement" by F. J. Feltoe.

B. Seminar on Energy Monitoring and Targeting Programme in the Steel Industry.
Based on recent U.K. experience.

C. Comparative study for Egyptian and international energy consumption norms in the iron and steel industry.

D. Visits to:-
El - Nassr Forging Co.
Egyptian Iron and Steel Co.
Delta Steel Plant.

Comments and Results of Mission.

As the above programme had to be compressed into five working days, items C. and D. were brief, and concentrated upon handing over a considerable amount of information and literature, including norms or "standards", which the author had prepared. The collection of similar information from the Egyptian steel industry should be undertaken as soon as possible. Limited comments on present performance are made in Section D.

The programme was modified from the original, which made specific reference to the textile industry. Therevised programme, however, whilst using the Iron and Steel Industry as an example, was intended to introduce energy management techniques which could be applied to all industries.

Despite the brevity and alteration of the programme, the result appeared to be very successful. The papers and information were enthusiastically received, and, in particular, the concept of monitoring and targeting was grasped keenly - as offering an approach, which had been given much priority in the U.K. and could be considered, in Egypt, as a possible basis for achieving improvements in industrial energy performance on an industry-wide (i.e. "Strategic") scale. It was agreed that "M. and T." could complement (a) previous missions dealing with specific technical matters, (b) the present technical training and support activities, more related to high-cost investment in plant and equipment.

The effect of subsidised energy prices in Egypt was reported to be, that in the various iron and steel works, energy represented no more than 5% of total operating cost. This contrasted sharply with 15%/35% in the U.K. The latter is in some cases, higher than labour costs, and provides urgent incentives to management to reduce energy consumption.

It is possible to operate a monitoring and targeting programme using only energy units (Gigajoules; Kilo-calories, therms etc.) but experience in the U.K., is that cost is better understood and more effective, as a basis for management action.

The following sums up the "raison d'etre" for monitoring and targeting.

TO MANAGE ANYTHING, ONE MUST MEASURE IT, AND THEN AGREE CURRENT STANDARDS AT WHICH TO AIM: FOLLOWED BY THE ESTABLISHMENT OF TARGETS FOR LONGER TERM IMPROVEMENT.

RECOMMENDATIONS

1) Bring to the attention of senior people in Government and Industry, that the "Monitoring and Targeting" method of Energy Management offers a mechanism and strategy for reducing industrial energy usage with only minor expenditure on installing the system. It provides a numerate basis for decisions on operating practice and on plant investment (to achieve further savings).

Further study of U.K. experience is recommended, followed by a pilot programme in selected industries

Line-Management accountability for energy performance requires particular attention.

2) Use and modify the Tabbin Institute (and similar bodies) training programmes to help implement energy management techniques, including "monitoring and targeting" in industry. This could cover the introduction of the systems to selected works and the "auditing" which forms one step in the assessment of energy performance.

Consideration could be given to the training of a "technician" grade, to assist the more highly-qualified staff in field-work at various industries.

3) Study and apply the information on iron and steel industry energy standards, (or "norms") supplied by the author, and, as soon as possible, collect a similar set of data for selected Egyptian iron and steel works.

This may involve a study into the means of establishing these standards (eg. as in "standard Costing" systems).

4) Consider means of introducing true (international) energy costs into management information systems, in order to sharpen the incentives for appropriate management action to reduce energy consumption.

5) Establish a stock of basic flow instruments (in addition to those in the energy bus) for the short-term measurement of energy usage in factories participating in a M. & T. programme.

MAIN REPORT

A. "Energy Management Techniques in the Iron and Steel Industry".

This seminar was based on the two papers reproduced in full as appendices. These give considerable detail on the energy management policy, and practice, of the British Steel Corporation and the U.K. Private Steel Sector, and on the opportunities for, and obstacles to, achieving improvements.

The following section of the report has, therefore, been kept short to avoid repetition, and simply summarises the contents.

First Paper.

1. Overall energy costs for the whole corporation amount to £780 million (sterling) per year, representing up to 35% of all operating costs, and approximately £40 (sterling) per tonne of liquid steel. 17% savings are believed possible.
2. Of this, 45% is "coal-based energy" and the percentage is being increased as a matter of policy.
3. Energy consumption in main processes, totalling 21.75 Giga-joules per tonne of liquid steel is analysed. The total represents a 27% improvement over 18 years, and, again for the whole British Steel Corporation, will soon achieve less than 19 GJ/tonne liquid steel - a good international standard.
4. Energy management is assisted by the tradition of "fuel departments", and by the use of standard costing systems.
5. "Policy Factors" (as compared with technical factors) affecting energy performance are explained.
6. "Operational Factors" (i.e. within the control of line management) are listed.
7. High capital cost possibilities (i.e. those less likely to be pursued) are listed, followed by details of lower cost measures which are in hand. Note that this section is amplified in a paper by "Hansrani", left with the Tabbin Institute.
8. Monitoring at Corporation and Works level.

   This section was dealt with in the second seminar on monitoring and targeting, (see Section C and D).

9. Summary of B.S.C's energy management policy, including the work of the "Energy Utilisation Committee", and the diversion of research efforts from "pure research", to energy auditing.

10. Particular reference is made to the role of line management as compared with that of the energy specialist i.e. the need for the former to accept responsibility for energy usage and cost.

Second Paper

This lists, in considerable detail the typical energy performance and opportunities for improvement in all the main and secondary processes of

It was supplied to all attending the seminar as a reference source, with present and future performance listed wherever possible.

Briefly, the obstacles to further improvement were also reviewed (eg. the return on capital considered acceptable) with the suggestion that energy conservation investment is essentially a low-risk investment and should therefore be sympathetically considered for "longer-pay-back" capital development.

B. "Energy Monitoring and Targeting Programme".

Background to M. & T.

This should be considered as being at the heart of the mission as it represents a cornerstone of present U.K. energy conservation policy, having evolved after the systematic introduction of several other types of incentive, by the Department of Energy. Details and many examples of the following measures were left with the Tabbin Institute and outlined at the seminar, as background to the more recent introduction of the "monitoring and targeting" methods of energy management.

1. "Energy Thrift Surveys":- Brief industry-wide reviews, by independent consultants of the energy situation in approximately 45 industries.
2. "Energy Audit Surveys":- Comprehensive and detailed examinations by Dept. of Energy Technical Staff (E.T.S.U. at Harwell) of the energy position in several selected industries.
3. "Save It!! Schemes":- Publicity drives intended both for industry and the general public, including the publication of guide-line booklets on many energy topics (eg. insulation; steam usage; boiler practice etc.)
4. "Subsidised Audits" by independent consultants (50% of cost)
   a) Short eg. one/three days
   b) Detailed fifteen days
5. "Demonstration Projects":- where 25% of capital cost is provided for the introduction (or new applications) of novel energy-saving equipment. The resulting experience must be made available to other industrial users.
6. "Energy Management":- the monthly newspaper of the Dept. of Energy, publicising much information on energy conservation in the U.K. Copies were left at the seminar.
7. "Breakfast Specials":- this is the vital, personal effort of the U.K. Secretary of State for Energy (at present, Mr. Peter Walker) to bring forcibly to the attention of top industrial management, the savings and profit improvement which can result from energy-saving.

   The method is that a team, headed by the Secretary of State addresses large gatherings (100 to 800 people) of senior industrialists, at early morning meetings at various towns in Britain. This "prepares the ground" at top level for the acceptance of energy conservation measures as and when they are introduced in respective industries.

Objectives of M. & T.

The main objective is to achieving energy savings quickly, over wide areas of industry, without heavy expenditure of capital, by the systematic adoption of simple measurement of energy usage, and the subsequent adoption of weekly, or monthly standards, at which to aim. This is followed by the identification of longer-term "target-savings" through changes of plant or practice. The acceptance of responsibility for the energy performance and cost by line (i.e. operating) management at senior and department level as compared with the specialist energy managers, is critical to the sucess of the monitoring and targeting.

How M. & T. is introduced to Industry.

1. Sectors are identified. In the U.K. at present, they include
   a) Paper and Board
   b) Textiles
   c) Ferrous Metals (Private Steel Sector: Drop Forgings; Iron Foundries and Steel Castings)
   d) Non-Ferrous Metals
   e) Aluminium
   f) Clay Procucts (bricks and pottery)
   g) Food Industry.

2. Each industry is approached via its "trade association" which persuades several to participate in a pilot programme, acting as "host companies"

3. These groups receive financial assistance to install basic instrumentation and to pay for consultancy, which is located and introduced by the Trade Association (eg. using private consultants, or Research Associations)

4. The pilot study has, typically, covered up to six companies in each industrial sector, and has lasted for $1\frac{1}{2}$ years (see below for the methodology).

5. Replication Phase:- The results of each pilot study are made available to to the entire sector (eg. 50 companies) using a manual prepared in the pilot phase , and short - up to three day - explanatory visits. The manual is important in facilitating expansion of the programme to larger numbers of factories.

Methodology of a Pilot Programme in the U.K.

Note:- this is explained in detail in a typical monitoring and targeting manual which the Tabbin Institute were shown in confidence. The manual constitutes a "child's guide" to the step by step introduction of M. & T.

1. The Trade Association becomes the "contractor" responsible for carrying through the programme. This is important as these Associations have the confidence of their member-firms.
2. It appoints consultants (possibly Research Associations) to actually carry out the studies.
3. Several "host companies" are sought and the incentives explained.

4. The full committment of top management is looked for. It is essential that this is secured before proceeding.
5. Brief preliminary studies are undertaken, to determine
   a) the level of energy monitoring already carried out (if any)
   b) the lay-out of works and their energy users
   c) additional minimal metering required to analyse the works and the departmental energy usage
   d) the present management organisation and its degree of accountability for energy usage; - and its committment
   e) possible proposed changes to d)

6. Design a format for reporting at all levels, from shop floor to senior management - monthly, weekly or even "per shift"

7. Collect preliminary data based on existing metering

8. Order and expedite additional metering (could cause delay)
9. Collect and collate data using new instruments
10. Assess present works and departmental performance.
11. Carry out formal energy audit (eg. assisted by the Energy "Bus"!!.
12. Report results to departmental and works management
13. Agree a set of initial standards for everyday performance, and a routine for reporting against them
14. Agree longer-term changes in plant or practice, in order of priority (and capital cost, if any)
15. Identify "target" savings attributable to these changes and a time-scale for their achievement
16. "Contractor" commences compilation of a manual based on the experience of several host companies

17. Throughout the above programme, ensure progress by means of a "steering committee" and site visits.

Replication Phase.

1. The Trade Association, in conjunction with the Department of Energy, agrees the programme, including the much more limited incentives to be offered to participants in this major phase.
   It is assumed that the evidence of the pilot programme will persuade others that it is very much in their own interest (in terms of savings and profit improvement) to participate.
2. In each sector, arrange a "launch" of the replication phase, preferably at a meeting of senior executives, called by the Trade Associates.
3. Make short (up to 3-day) introductory visits to each participant (consultant)
4. Carry through a formal routine of steering committee meetings and selective plant visits.

Problems Encountered (examples only)

1. Failure to convince middle management that such a simple approach can yield results and that it does not reflect upon their own performance.
2. Failure to retain the support of top management, due to other priorities
3. Excessive data collection overwhelming existing staff.
4. Delays in meter delivery.
5. Occasional insistence on sophisticated systems (eg. remote reading, or computer-based), when a simple system would have been appropriate.
6. Restriction of cost information to senior management.
7. Manual Preparation:- variable quality and input.

C. International Standards (Norms) in the Iron & Steel Industry.

The two papers forming appendices to this report, contain considerable detail on standards and achievements in energy performance, in the U.K., at four levels

1. Corporate Level
2. Works Level
3. Departmental Level
4. Plant Item Level

These were expanded upon in the seminars by an explanation of the development of a statistical system for reporting energy performance on a monthly basis, in the British Steel Corporation.
This has been greatly facilitated by the long history of using "Standard Costing", in which, over more than twenty years, annual reviews have been held to establish the standards at which to aim (for all costs).

In actual monthly use, the "annual" standard is further refined by the use of factors such as "level of output", which results in the production of a "flexed standard", and which then forms the principal aim-point for works management.
Examples of typical European, Japanese and American norms were given, at both of the seminars and in the specific discussions on this subject (Item C in the programme).

From such a brief visit it was simply not possible to express other than cursary opinions about the energy performance in Egyptian Industry, but much material was supplied for them and the Tabbin Institute to use as a basis for comparison.

Only a limited number of senior industrial management were met so that it is also not possible to express a view on the level of their personal committment to energy conservation. From experience in the U.K. this is of crucial importance and needs to be established from the most senior level, downwards.

D. Plant Visits.

Egyptian Iron and Steel Company. (integrated iron & steel works)

Accompanied by	:-	Dr. Eng. Ahmed Amin	:-	Tabbin Institute
Persons Met	:-	Mr. Eng. Fekry Abou Aref	:-	Director, Production and Energy Planning and Control.
		Mr. Eng. Rabie Rasslan	:-	Energy Manager trained at Tabbin Institute.).

The visit was confined to a meeting at which the purpose of the UNIDO mission (i.e. on Energy Management Techniques), was explained. Egyptian Iron and Steel representatives were advised of the European and other steel industry norms, left with the Tabbin Institute, and it was agreed, would study these after the seminars, following which some comparative figures would be produced.

The meeting concentrated on some specific, energy problems experienced at Egyptian Iron and Steel, in particular, those of the waste-heat boilers on the steel convecters. U.K. experience with boilers; water cooling and convecter gas-collection was outlined.

Some further discussion on the organisation of the energy department took place later, with Mr. Rabie Rasslan, and the manager of the electric arc furnace department. It was stated that there are five people in the department, engaged mainly in collecting energy figures which are issued as a computer print-out. The department had no technical role, and all operational matters (e.g. furnace operation) were left to the production and maintenance engineers. Energy was said not to be a regular topic either at the departmental or works level management meetings.

Time did not permit further examination of the organisation of energy matters but this needs consideration in the light of the advice offered at the seminars.

Delta Steel Company (Electric Arc Melting Shop, Foundry and Rolling Mill)

Accompanied by :- Dr. Eng. Ahmed Amin :- Tabbin Institute
Persons met :- Mr. Eng. Mahrous Hanna :- Energy Manager (trained at the Tabbin Institute)

After explaining the purpose of the mission, this visit consisted of a discussion on energy organisation and a tour of production departments.

Organisation:- The Energy Manager has eight staff, most of them trained at the Tabbin Institute. The majority are allocated to production departments where they advise the manager on the technical operation of plant, and also collate energy performance figures.

Regular meetings on energy are held, and it is a regular subject at management meetings. Members of line management were not met, but the impression was gained that there is an active consciousness of energy usage and costs, and that it has some priority.

Plant. Three new items of plant were visited, all of which will contribute to better energy performance (not quantified)

1. Continuous casting plant - about to be commissioned
2. Rolling mill re-heat furnace - recently commissioned
3. Steel Foundry induction furnace - recently commissioned

The intention is to double the steel throughput of the melting shop and rolling mill when the continuous caster is commissioned, and this will contribute substantially to lower energy usage, per tonne of production.

El Nassr Forging Company. (Drop Forge making (E.G.) crankshafts)

Accompanied by :- Dr. Eng. Ahmed Amin :- Tabbin Institute
Persons met :- Forge Manager

This was a very brief visit but the company and its equipment was very similar to many in England. The same problems were evident e.g. furnaces without instrumentation and under manual control. In the U.K., the monitoring and targeting programme in the drop-forging sector is very relevant to the activities of the El Nassr Forging Company, and hopefully, it will be possible to provide some information on this programme at a later date. Individual fuel metering and the related production output figures would be an initial requirement, ANNEX 1

'ENERGY MANAGEMENT

IN THE BRITISH STEEL CORPORATION'

INTRODUCTION

British Steel is one of the largest individual consumers of energy in the United Kingdom, accounting for over 20% of all industrial energy consumption, and 7% of the country's total energy consumption.

At current levels of output, the Corporation's annual energy bill is £780 million, whilst that of the total United Kingdom Steel Industry approaches £1,000 million.

When introducing the Department of Energy's recent 'audit' of the Iron and Steel Industry, the Under Secretary of State for Energy, Mr David Mellor, indicated that a possible annual saving of £130 million could result from present efforts on energy conservation allied with further major capital investment.

Depending upon the type of steelworks and process route involved, energy costs may amount to £40 per tonne of liquid steel and account, on average, for more than 35% of all operating costs.

These figures indicate a clear and financially critical 'target' from which has been developed a three year energy plan for each of the numerous works within the British Steel Corporation.

CONTENTS

In the current surge of effort to manage energy costs, BSC enjoys two useful benefits -

a) the existence of long-established fuel departments in the larger Works,

and

b) a long-standing commitment to standard costing.

This means that it is normal practice to produce standards, monitor performance against them, and to have the means of securing action, within the Works themselves.

Based on a cautious view of BSC's current activities, operational plans and fairly limited investment, a saving in specific energy cost of between 7% and 12% over three years appears possible. However, the potential cost reduction mentioned by Mr Mellor, and referred to in the Introduction to this paper, represents a possible improvement of about 17% on present costs. To achieve this target, it will be necessary to intensify the energy management effort, and to adopt some of the high-capital measures open to us - for example, Gas recovery from oxygen steel-making, and high-top-pressure turbines on blast furnaces.

ENERGY CONSUMPTION OF MAIN STEELMAKING PROCESSES

The following table details the average energy consumption, by process, for all iron and steelmaking facilities within BSC, for the month of October 1981 - a "good" month, with no interruption to production as a result of holidays. (A number of non-integrated finishing plants were excluded from the analysis).

PROCESS	ENERGY CONSUMPTION PER TONNE LIQUID STEEL	
	GJ	%
Coke Making	2.58	11.9
Sinter Making	1.33	6.1
Pellet Making	0.17	0.8
Iron Making	9.38	43.0
Steel Making	0.73	3.4
Concast, rolling and finishing	4.55	20.9
Power Generation	0.65	3.0
Boiler Plant	0.73	3.4
Other Activities	1.22	5.6
Losses	0.41	1.9
TOTAL	21.75	100.0

It is important to note that, despite the fact that cokemaking, ironmaking and hot rolling together represent some 75% of the total spend, some of the best short-term possibilities for saving lie in the other areas.

A breakdown of energy consumption by process, as shown in the above table, is the essential first step in producing a target for each of the principal processes. As an indication of progress over the years, the typical total energy consumption shown, of 21.75 GJ/tonne of liquid steel, compares with a 1964 level of almost 30 GJ/tonne, at which time the long term target was 25 GJ/tonne. A substantial improvement - of over 27% - has been achieved over the 18 year period, by the rationalisation of the industry, concentration on larger works, the adoption of oxygen steelmaking and, to a lesser extent, the introduction of continuous casting technology.

PRINCIPAL 'POLICY' FACTORS AFFECTING ENERGY CONSUMPTION

1. Arc Furnace Steel Proportion
2. Energy Mix
3. Coal/Iron Ratio
4. Sinter/Iron Ratio
5. Iron/Steel Ratio
6. Output Level
7. Holiday and Shut-down Policy
8. Plant in service

The energy 'penalty' associated with each of the above policy decisions needs to be more clearly understood than in the past.

Energy Consumption in any steel industry is heavily dependent upon these policy decisions which are often taken with only secondary regard to the energy 'penalty'. Up to now, Energy Managers have not played much part in making these decisions.

1. Arc Furnace Proportions

Integrated Works	take 84%	of all	energy	consumed
Arc Furnace Works	" 8%	"	"	"
Non-steelmaking Works	" 8%	"	"	"

2. Energy Mix

This is highly significant, and much of the cost improvement, particularly in integrated works, is due to the movement towards the increased use of coal-based energy. The use of blast furnaces as gas producers is one example of this, and even with the stabilising of prices for electricity, gas and oil, considerable benefits emerge from increasing the coal proportion.

3. Coal/Iron Ratio

This reflects the relative rate of making coke and iron and the consequent stocking/destocking/sale of coke. This is essentially an 'energy bank', but it can, and does, distort apparent energy consumption.

4. Sinter/Iron Ratio

This reflects the burdening policy on the blast furnaces - an operating decision which is not usually determined by energy considerations, but which can significantly affect energy consumption.

5. Iron/Steel Ratio

This reflects the scrap ratio policy and the level of iron granulation or plating. From an energy point of view, this is the single most important ratio as it also affects the energy 'balance' and the level of losses throughout the plant.

6. Output level, particularly Steel Outputs

Quite obviously, this is of great significance. Performance settles down with well-loaded plant but, as the principal divisor for energy figures, a low steel output also emphasises an apparent overall worsening of the energy situation, particularly if mill and finishing outputs are high.

7. Holiday Policy

There is a need for more analysis of the energy cost associated with holiday breaks. Taking two of BSC's integrated steelworks as an example; during the period from November to December 1981, Llanwern's energy consumption (per tonne) rose by 13%, whereas Scunthorpe's rose by only 5%. Whilst there were other factors to take into consideration, it is nevertheless interesting to note that the Llanwern Works took a 10 day break whilst Scunthorpe's break was shorter.

8. 'Plant in Service' Policy

For example, operational considerations such as -

Two blast furnaces, or three?

How many soaking pits?

How many re-heat furnaces?

- are vital decisions from the point of view of energy consumption.

This is a most important policy area. If these decisions on how much plant is required in service at any one time always have to err on the side of caution ("belt and braces") - because of doubtful availability, for example - the cost of energy will be impossibly high. Such decisions are usually made under pressure of other events; nevertheless together with the following engineering and operating factors, they represent a major reason for our lagging behind Japan on energy performance. As an example, the use of four reheat furnaces for a scheduled load which only requires, theoretically, 3½ furnaces, can carry a heavy energy penalty; however, methods exist (such as running without the preheat zone) which can turn this to an advantage.

AREAS OF ENERGY PERFORMANCE SIGNIFICANTLY UNDER THE CONTROL OF ENGINEERS AND OPERATING MANAGEMENT.

1. Plant availability
2. Steady Operation of plant - particularly services.
3. Maintenance and condition of plant and services.
4. Original choice and subsequent development of plant for maximum fuel economy.
5. Correct 'technical' operation of production plant by operators and production management, including training.
6. Operation of power plant and distribution of steam, gas, etc.
7. Consequential yield losses - which carry heavy energy investment.
8. The diligent application of long-known techniques.

None of the above statements is new or original but, together with the policy factors, they are heavily responsible for the short falls in our energy performance compared with that of our competitors.

This is particularly true in relation to Japan. Where comparisons have been made, much more of Japan's success is due to the above (particularly Item 8) than to their advantage in capital equipment. There is, at present, far greater potential benefit for BSC in applying known, common-sense techniques than in chasing some of the very high capital investment possibilities.

To lend weight to the last statement, which I consider of considerable importance, the following are a few examples of major capital - intensive developments which we are currently pursuing on only a limited scale.

- Dry Coke Cooling
- B.O.S. Gas Recovery
- Heat recovery from slag.
- Heat recovery from hot slabs
- Coal Gasification
- Coal briquetting
- Sinter cooler heat recovery
- Top-gas turbines for blast furnaces
- Heat recovery from soaking pits and slab furnace skids
- Coal/coke/oil injection into blast furnaces.

Some less costly developments which are being investigated more actively and which rank alongside better day-to-day operation in importance are:

- Optimisation of stove control
- Blast humidification
- Reheat furnace delay strategy - computer control
- Utilisation of oxygen bleed
- Stove recuperation
- Reduction in rolling temperatures) i.e. questioning
- Modifying thermal profiles in reheat furnaces) the metallurgy.
- Direct rolling and hot charging
- Mill heat shields
- Alternatives to steam for purging, ejection, descaling etc.

MONITORING AT CORPORATE (AS OPPOSED TO WORKS) LEVEL

The two tables reproduced at the end of this paper indicate the form in which the energy performance of each works and each major department, has been reported each month.

Developments are in hand to improve reporting against standard, in terms of both energy and cost - a task of considerable complexity in an organisation as large as BSC.

This information - flow tends to be used to keep senior management informed of the broad situation, but is also used by the Energy Utilisation Committee - the principal committee of Energy Managers and specialists in the Corporation - to help develop action programmes and priorities.

The following pages indicate some of these and some of the practical measures being introduced or considered.

BSC's PRESENT EFFORTS IN ENERGY MANAGEMENT

General

My contacts and information from outside the steel industry suggest that we are not doing too badly in the level of effort which we apply, but the prizes and penalties are so much higher in the steel industry that we cannot possibly be satisfied.

Capital

We are quite well served for capital, particularly for medium sized, rapid pay-back schemes. There has been a good increase in the number of such schemes authorised but there is a continuing need to identify, quantify and justify even more. A close link between the Works Fuel Departments and those responsible for capital development is essential if we are to specify and engineer these schemes quickly. They need to be done properly, and such a large number of small to medium sized schemes is bound to be engineer-intensive.

A catalyst is needed to help operating management to identify good schemes. An Energy Manager for each establishment is the ideal solution but Works Fuel Technologists, R and D 'attached staff', graduate trainees, etc., can all help to fill this rôle. Efforts need to be made to give some energy training to as many young engineers as possible so that they know where to look for cost-saving possibilities, which they can then take on to completion.

Works Level

Support from the top is as good now as it has ever been, but at Works management and departmental level there is still, in some cases, insufficient awareness of the level of input and resources needed to manage energy. With energy costs representing 35% of total operating cost, this is surprising, but there is still a tendency to regard energy management (or fuel technology, to give it its old name) as a matter for the specialists. As the most effective action can take place at Works and departmental level I believe that, at present, five priorities exist in day to day management, (as opposed to the technical and capital areas, which tend to attract more attention):

1. Good weekly and monthly information on energy use and cost, at works, departmental and major plant item level, and regular routine meetings to analyse this information.

2. Use of our own staff, and outside help (i.e. consultants) to increase the <u>awareness</u>, at <u>all</u> levels, of what needs to be done and what can be achieved This is a big task.

3. Flowing from this, recognition of the fuel technology resources needed on a day to day basis to manage the expenditure on energy.

4. Retain, regain or retrain the skills and discipline of furnace and boiler operation.

5. Give full value to energy cost as a factor in production and engineering decision making.

<u>Corporation and Divisional Level</u>

1. <u>Energy Utilisation Committee</u> (E.U.C.)

   This is one of the longest established and most active committees in BSC, meeting bi-monthly. As a forum for Energy Managers and specialists, it does a good job in looking at common problems, and at developments worldwide.

   Over the last two years, a lot of effort has gone into establishing good, usable statistics and it is undoubtedly true that since April 1981, despite gaps, inter-works comparisons have been made easier and more reliable. Present efforts are being concentrated on filling the gaps, and on incorporating cost information as well as 'gigajoules' consumption data.

2. <u>Divisional Committees</u>

   These can be of particular help to the small works which jointly have an annual energy bill of over £100M, and which tend to be overshadowed by the integrated works.

3. Use of R and D Departments

There has been an increasing and very helpful emphasis by R & D Energy Departments on assisting works with day to day problems, in addition to their normal research and longer term technical work. Particularly noteworthy is the skill being developed in energy auditing. The style of audit tends towards in-depth analysis of processes and the inter-relationship of processes, and is vital for the very many small works who do not have specialist staff.

Over the next two years, at least, these audits will be given a lot of priority in the R and D Departments' programmes, in order to satisfy the demand for such services, which itself reflects the importance and potential value of the audits.

One way to improve the results from these audits is for the works to allocate one or more young engineers to work with the R and D team. This ensures the participation of works staff, and contributes to their training in energy management.

4. Internal Audit Energy Surveys

The Internal Audit Department of the BSC, as a contribution to energy saving, is following a policy of conducting surveys of works steam distribution systems and, initially, is concentrating on coke-ovens. The result is straight forward, and helpful to the engineer and department concerned.

A fair proportion of the R and D type audit mentioned above is in very 'ordinary' areas, such as compressed air and electricity utilisation, and the combined effect of this work, together with the Internal Audit work, will undoubtedly contribute to a good reduction in wastage and cost.

5. Consultants

The sheer size of BSC and the corresponding scale of the task which energy management presents, must be kept in mind and, on the basis that we need to save money quickly, there is a need in certain areas for some consultant-based assistance.

6. E.E.C. and U.K. Energy Grants

E.E.C. Demonstration Project Grants offering 40% contribution to suitable capital schemes and U.K. grants offering 25%, are still available. There is an administrative work load associated with this, but BSC is endeavouring to take more advantage of this source of finance.

CONCLUSIONS

1. BSC's effort in energy management is accelerating, and needs to be sustained.

2. We know what to do but by no means always do it.

3. Large savings are possible - particularly in the 'low technology' areas.

4. We should restore the former importance of fuel technology, both short term and long term, in our training of engineers and other technical management.

5. Operating managers need to accept that energy cost is 'their cost' and needs to be managed.

6. The engineer's rôle is central - in guiding others and in providing plant and practices which match todays energy costs.

7. Targets and means of monitoring are rapidly becoming an accepted part of the Corporation's energy management effort, and they are helping to develop a strong forward programme of improvements, both in equipment and operating practice.

ANNEX 2

Energy Management in the Steel Industry - Surmounting the Barriers to Technological Improvement

INTRODUCTION

The annual energy bill of the steel industry in the United Kingdom approaches £1,000 million and in some sectors this represents up to 35% of all operating costs - a clear and financially critical target.

The Department of Energy's recent audit indicated possible savings of £130 million per annum, amounting to about 17% - by a combination of present energy conservation efforts and the introduction of further substantial capital investment.

Analysis within British Steel shows that present efforts are likely to produce savings of between 7% and 12%, depending on the sector being considered, so that a substantial proportion will only be achieved if investments, presently considered too long term, are proceeded with. This is perhaps the most obvious barrier to technological improvement and one which will be surmounted only if the low-risk nature of energy conservation investment is recognized and attracts the necessary capital.

It is essential to establish the total picture of possible technical improvements, and Part 2 of this paper attempts to identify most of the many possibilities, ranging from coke-making to final finishing operations. Figure 1, may help to focus on the extent to which various products use energy, and the relative usage of coal-based to other kinds of fuel.

However, reduction of energy costs depends upon more than technical improvement. Part 1 of the paper briefly discusses the role of energy management (a) in producing savings in its own right, and (b) in establishing an order or priority for the technical changes listed in Part 2.

PART 1. Energy Management

It is assumed perhaps optimistically that, at 35% of all operating costs energy has now earned the right to be recognized as a management discipline, and that operating management (as distinct from engineers and technical support staff) will take it on board as "their cost", along with labour and yield costs.

Policy Factors

Energy consumption in the steel industry is heavily dependent upon a number of policy decisions, which are usually taken at high level, and with only secondary regard for the energy "penalty" associated with them. A first step in "senior energy management" is to be aware of the cost penalty in such things as:-

1. The proportion of arc furnace steel in relation to steel made from other sources.
2. The energy mix, particularly in increasing the proportion of coal-based energy.

3. In integrated works, the key ratios of coal/iron; sinter/iron and iron/steel.
   These reflect the success of synchronising consecutive processes on which energy savings or waste, are created.

4. Output level; shut down policy; plant kept in service.
   The achievement of steady economic plant loading is, of course a key factor in energy cost control.

Local Management Factors

At the next level down, there are a number of areas of energy performance which are significantly under the control of engineers and departmental management, eg.

1. Plant availability
2. Steady operation of production plant and supporting service
3. Maintenance and conditions of plant
4. Original choice and subsequent development of plant for maximum fuel economy
5. Correct operation of plant and the associated training
6. Operation of power plant and distribution of steam, gas etc.
7. Yield losses - which carry heavy energy investment
8. The diligent application of long-term techniques

None of the above statements is new or original, but, together with the "policy" factors, they are responsible for much of the short-fall in our energy performance, compared with competitors. This is particularly true in relation to Japan. Where comparisons have been made, much more of Japan's success is due to the above (particularly item 8) than to their advantage in capital equipment.

Distribution of energy cost in a typical integrated works

Process	Energy consumption per tonne liquid steel G.J.	%
Coke	2.58	11.9
Sinter	1.33	6.1
Pellet	0.17	0.8
Iron	9.38	43.0
Steel	0.73	3.4
Concast, rolling + finishing	4.55	20.9
Power Generation	0.65	3.0
Boiler Plant	0.73	3.4
Other Activities	1.22	5.6
Losses	0.41	1.9
	21.75	100.0

It is important to note that despite the fact that coke-making, ironmaking and hot rolling, represent some 75% of the total spend, some of the best, short term possibilities for saving lie in the 'peripheral' areas. Some of these are operational changes of no capital cost, and many are simple, low-cost technical changes.

Just a few examples of these less costly technical and energy management developments are as follows:

1. A more realistic approach to space-heating, and a recognition of the futility of attempting to heat enormous buildings.
2. An equally realistic view of the old problem of protecting stock from rust by dispensing large amounts of low-grade heat, to no useful purpose.
3. A rigorous approach to the process use of steam and compressed air. The practice of previous decades in the lavish use of steam, even though efficiently produced eg (from blast furnace gas) and using the best of back-pressure turbine technologies, is no longer valid.
4. Furnace delay strategies, together with possible reductions in furnace temperatures and profiles i.e. the cost of energy now forces some questioning of long established operating practices.
5. Direct rolling from soaking pits; hot charging of reheat furnaces and the use of mill-heat shields.
6. Improvements in recuperation in all plant - stoves, soaking pits, reheat furnaces and annealing furnaces, including the wider use of self-recuperative and new regenerative burners.
7. The commissioning of energy audits and surveys, including the diversion of R and D effort towards this time-taking but effective type of exercise.
8. The establishment of good statistics, based on the relationship of energy to output, and their scrutiny at departmental and works management level.
9. The training of young engineers in some of the old fuel efficiency techniques and the use of these engineers as catalysts between operating staff and development engineers.

It can be seen that all of these, in one way or another contribute to technical improvement, or to the lowering of barriers which may exist to their achievement.

PART 2 - TECHNICAL IMPROVEMENTS

A. The immensely complex energy flow of a modern steelworks is shown diagrammatically in figure 2. This illustrates the scope for heat recovery but, as a somewhat negative start to this review of such opportunities, the following are a few of the high capital cost innovations which, at present are not receiving high priority in the U.K. steel industry.

- Dry Coke Cooling
- B.O.S. Gas Recovery
- Heat recovery from slag
- Heat recovery from hot slabs
- Coal Gasification
- Coal Briquetting
- Sinter strand heat recovery
- Blast furnace top-gas turbines
- Heat recovery from re-heat furnace skid cooling systems

PART 2 (cont) - B

DESCRIPTION OF PROCESSES AND ENERGY CONSERVATION OPPORTUNITIES

COKE OVENS

Description of Process

Coal is heated, in the absence of air, in a multiplicity of vertical sealed, refractory chambers, using, as a cource of heat for the "under-firing", blast-furnace gas, coke-oven gas, or a mixture. Coke-oven gas is produced during this process, and is drawn off, cooled and by-products recovered, the gas then being distributed as a major fuel in the steelworks, a) for heating the coke-ovens themselves, b) for use in other steel-works furnaces, c) for firing boilers, to produce steam, either for process use or for power generation.

After a period of hours, the red hot coke in each oven is pushed out and quenched to terminate combustion.

12% of total energy consumption, in an integrated works, is taken by the coke ovens.

Energy use and conservation

(a) present position

* 1. Coke (at 1,000°C) is normally quenched with water, the sensible heat being lost.
2. Efforts are made to programme and control carbonisation to minimise the energy used in underfiring and to imporve the quality of the product.
3. Operational practice aims at minimising the loss of gas from the coke-oven batteries and maximising the gas made available to the works.

* 4. The gas arising from the ovens is hot and has to be cooled. This sensible heat is lost.
5. Steam utilisation in the coke-ovens is optimised eg. by the use of steam-driven exhauster fans.

(b) potential for further improvements

* 1. Coke dry quenching, or alternatively, wet quenching with heat recovery is possible. Both are high capital cost (less than 15% return on capital) and are only practised at a few steelworks in Japan and U.S.S.R., none in the U.K. There is an increasing interest, as air pollution is reduced, but adoption in the U.K. is unlikely at present.

   In the former case, inert gas is continuously circulated through the hot coke, in a sealed car, and energy recovered as steam, hot water, and water-gas.
2. Computer control and fully programmed heating are now being introduced.
3. Disciplined coke oven management and maintenance are now standard.

* 4. Heat recovery from the hot coke oven gas is being investigated.

   Low boiling-point fluids are used, either to preheat the underfiring gas or to raise steam for power generation.
5. Critical evaluation of steam usage and loss is being increasingly carried out.

Note: * indicates an area of potential saving.

SINTER PLANTS

A mixture of iron ore, coke breeze and limestone is ignited on a moving grate, or strand, the granulated sinter thus formed, producing a suitable burden for the blast furnace. Ignition is achieved by burning fuel (gas or oil) in a hood. The products of combustion from the sinter bed are drawn downwards to the gas cooling and cleaning plant. The hot sinter is cooled by air, on a second moving strand.

The sinter plant typically consumes 6%/9% of all energy in an integrated works.

Energy use and conservation (a) present position

1. The use of coke breeze is minimised (within strict limits on the quality of the sintered product) in the design and operation of the main sinter strand.
* 2. Energy consumption for ignition depends on good combustion control in the hood.
3. Heat in the main strand exhaust gas and in the sinter cooler exhaust gas is lost.

(b) potential for further improvements

1. Good operating practice has to continue and improve (eg. bed-permeability).
2. Ignition-hood combustion control is becoming increasingly fully automatic.
* 3. (I) Although main strand exhaust gas is at between 300°C and 350°C, operational maintenance problems on heat recovery equipment are high, largely due to sulphur content. Gas volumes are high, but heat recovery - in waste heat boilers - is not commonly practised.
(II) Heat from the sinter cooler at between 300°C and 400°C is recovered in about eight locations - none in the U.K. - employing various methods such as preheating the strand burden before ignition; preheating the combustion air in the ignition hoods; and steam raising.

BLAST FURNACES

As the largest consumer of energy in an integrated works (between 43% and 55%) the blast furnace has been the subject of many years of technical investigation.

Description of process

A mixture of iron ore and/or sinter, coke and limestone is fed into the top of the furnace, typically, up to 14 metres diameter at the hearth and about 35 metres in height. Air at up to 4.0 bar pressure and 7,000 Nm^3/min volume is generated in turbine or electric blowers, and preheated to over 1,000°C in stoves, before being blown into the base of the furnace. Oil and oxygen are sometimes injected at this point.

The burden descends, and melts continuously; molten iron and slag being separately and intermittently tapped off.

Hot, combustible, dust-laden gas rises through the descending burden, pre-heating it, and leaving the top of the furnace at about 95°C and a pressure of 2.5 bar. This blast-furnace gas is reduced in pressure, cooled and cleaned and distributed as a principal fuel in the integrated steelworks..

Energy use and conservation (a) present position

1. For many years, the principal energy "aim" has been to minimise the amount of coke used per tonne of hot metal produced. This "coke-rate" with good modern practice is about 470 Kg/t.h.m. Further reduction can be counter-productive eg. by reducing the calorific value of the blast furnace gas to an almost unusable value, (eg. 76 BTU/Cu.ft; 680 Kca./m3 or 2847 KJ/M^3.
* 2. The stoves, used to preheat the furnace blast air, are large vertical, "reversing regenerators", fired with a mixed BF and Co gas, selected to help achieve the required air temperature. Although one of the largest single users of energy, recuperation, to preheat the combustion air, has not been usual practice, and combustion control has been only basic.
3. The pressure energy in the hot gases leaving the top of the furnace is not recovered.
4. The works power plant is usually one of the largest consumers of blast furnace gas, and is the supplier of blast air to the furnace. A complex set of energy considerations exist, but are dealt with under a separate heading.
* 5. The hot slag, tapped from the furnace is water-quenched.

(b) potential for further improvements

1. The "coke-rate equation" has to be continuously optimised in the light of energy costs eg. currently fuel oil is <u>not</u> injected and an important target is to satisfy all of the works requirements with coal-based energy, in the form of B.F. and C.O. gas.
* 2. Recuperators, preheating the stove combustion air to 200°C are becoming normal practice on new plant.
* 3. Several steelworks, in Japan and elsewhere are introducing top pressure turbines to recover the pressure energy of gases leaving the furnace top. (Up to 35 KWH/tonne of hot metal).
4. See "power plant".
* 5. Regarded as technically unproven, and of high capital cost, the recovery of heat from slag is being investigated in some parts of the world. Two problems are dust, and the intermittent nature of the slagging operation.
6. Some smaller heat saving possibilities exist, such as the insulation of cold-blast air mains from the power plant to the stoves.

POWER PLANT

Description of Process

An integrated steelworks power plant exists:-

a) to provide blast air to the blast furnaces.
b) to consume all blast furnace and coke oven gas not absorbed by the rest of the plant.
c) using these gases and supplementary firing of fuel oil, natural gas, or coal, to raise steam to drive the blowers, turbo-generators and for direct use in other processes, and for space-heating.
d) to generate electricity "as required", this being dictated by a complex balance of operational needs and cost, which differs from plant to plant.

Energy use and conservation (a) present position

Most steelworks have power plants using high-pressure boilers, and a combination of back-pressure, pass-out, and condensing steam turbines to give optimum efficiency. Steam distribution around very large areas is practiced, both for heating and process use, and in some works waste heat boilers contribute steam to this system.

(b) potential for further imporvements

This lies in examining on a continuing basis, the economic balance of such things as purchased -v- generated electricity, the practicality of heating large buildings and of distributing steam to them: and the case for waste heat boilers -v- recuperation on steel reheating furnaces.

STEEL PLANT

Description of Process

Molten iron is transferred from the blast furnaces to the steel plant in ladles and either stored in a large refractory-lined holding vessel, or poured directly into the convector. Virtually all steelmaking is carried out by blowing pure oxygen into molten iron in a large tilting vessel referred to as a basic oxygen furnace (B.O.F.)

Most steel plants will have two or three B.O.F. vessels, each of up to 350 tonnes capacity. Typically about 25% of cold scrap can be added to the hot metal charge.

The "blow", lasting, perhaps, 20 minutes reduces the carbon in the metal to, typically 0.1% and steel is tapped from the convector at about 1,650°C for transfer to either a continuous casting plant, or to ingot moulds.

During the blow, gas at high temperature is released from the vessel and must be cooled and cleaned before flaring to atmosphere, or collection. By suppressing combustion (ie. by preventing ingress of air), this B.O.F. gas will have a calorific value of about 243 BTU/Cu ft (2150 KCal/m^3).

The steel making process consumes approximately 3.5% of total energy used in an integrated works.

Energy use and conservation (a) present position

1. Maximum use of scrap is an important method of reducing energy consumption and is, at present, an aim of most steel plants.
* 2. Fully, or partially, suppressed combustion of the gas arising during steelmaking is normal in the U.K., as compared with earlier systems which burned the gas immediately above the convector, in boilers or water cooled heat exchangers. However, its collection for actual use as a fuel gas is not yet carried out in the U.K. as in some Japanese and European works.
* 3. The balance of energy consumed is for tundish and ladle drying and preheating.

(b) potential for further improvements

1. General improvements in practice (eg. to stop heat loss etc.) will permit a small increase in the amount of scrap to be melted in B.O.F. vessels.
* 2. B.O.F. gas collection will be adopted when opportune in more U.K. works and further consideration may be given to evaporative cooling in the hoods immediately over the vessel.
* 3. There is limited scope for the adoption of high efficiency or self-recuperative burners in ladle drying.
4. Track times to the subsequent processes can be further shortened (and heat loss reduced) by tight material movement control.

CONTINUOUS CASTING PLANTS

Description of process

Preferred practice for producing slabs, blooms or billets, is now to take the steel ladle from the convector and to cast the product directly, in a continuous ribbon, in a continuous casting machine.

Energy conservation and use (a) present position

* 1. Energy is used for preheating the tundishes through which the steel is poured into the machine.
2. Energy is saved inherently by continuous casting, as it eleminates the ingot heating and rolling stage.

(b) potential for further improvements

* 1. Self recuperative burners can be used, but there is a tendency towards the use of cold linings - requiring no heat to condition the refractory.
2. An aim of 100% continuous casting is necessary if the inherent savings are to be realised. Otherwise - if a small amount of ingot casting, heating and rolling is retained, there is a strong tendency for this to be intermittent and inefficient - cancelling out the concast gains.

SOAKING PITS (before primary hot-rolling)

Description of process

After teeming, depending upon quality requirements and logistics, ingot track time, before charging into the soaking pit may be between 2.5 and 7.0 hours. A typical refractory-lined soaking pit, of which there may be a large number, holds up to 200 tonnes of ingots, charged by crane from above. With the horizontally sliding lid in position, the pit is fired from one end with enriched blast furnace gas (108 BTU/Cu. ft; 950 KCal/nm^3) and the ingots heated to about 1300°C.

After soaking for a period at temperature, the charge is drawn and immediately rolled in the primary mill.

Energy use and conservation (a) present position

1. Track time and heating programme are optimised manually.
* 2. Air is preheated to 600°C and fuel gas to 400°C, both in metallic recuperators. Regenerative heat recovery has been used in the past, and in certain cases, waste heat boilers are substituted. Gas temperature leaving the pits is usually about 1200°C, requiring temperature dilution.

(b) potential for further improvements

1. Computer controlled programmed heating and combustion control is being adopted.
* 2. Alternative methods of combined ceramic/metallic recuperators are being researched.
3. Ceramic fibre linings are being adopted for soaking pit wall and roof.
* 4. Waste heat boilers can be considered, eg. if a clear demand for steam exists.

REHEATING FURNACES (before secondary hot-rolling)

Description of process

In a major integrated works, there may be only between three and five re-heat furnaces to handle the whole throughput, (as compared with, say up to 30 soaking pits). The unit sizes are, therefore, large.

Slabs or blooms, from the continuous casting plant or primary mill are usually sorted and scheduled in a stock yard, before charging into the reheat furnaces, where they are brought up to a temperature for secondary rolling eg. to hot coil, billet or section.

Several types of furnace are employed eg. (a) walking beam furnaces, and (b) top and bottom fired pusher furnaces for slabs and plates, (c) top fired pusher furnaces, and (d) bogey furnaces, for sections etc.

Energy use and conservation (a) present position

1. Blast furnace gas substantially enriched with coke oven gas is frequently used (283 BTU/Cu. ft; 2500KCal/nm^3, 10,607KJ/nm^3) but some furnaces are oil fired.
2. The product is normally charged cold into the furnace.
* 3. Most furnaces have recuperators, raising the combustion air to between 250°C and 500°C.
* 4. Furnace cooling is normally by water, the heat being lost.

(b) potential for further improvements

1. The choice of gas mixture and calorific value can be optimised (a) to improve efficiency and (b) to help the works gas balance.
2. Increasingly, hot-charging to the furnace, and occasionally direct rolling, without passing through the furnace, are attempted, where scheduling and quality problems can be overcome.
* 3. Recuperator design is being re-considered in order to raise preheat temperature. For example a ceramic heat-wheel is being developed. Preheating of the fuel gas is also under consideration.
* 4. Evaporative cooling of furnace skids etc., which has been employed in a few works for many years, is being extended - particularly where there is a clear demand for the steam. Waste heat boilers have been used quite frequently, and can be an alternative, or addition to recuperators.
5. Miscellaneous measures are:- better combustion control, use of ceramic fibres; better skid-insulation systems; programmed heating and furnace "delay strategy" systems.

COLD ROLLING AND FINISHING

Description of process flow (after secondary hot rolling)

1. Heavy plates:	About 20% of plate production is heat treated in either a quenching/tempering or a normalising furnace, before being cut for sale.
2. Billets/Rod and Bar:	The rod or bar mill, following billet reheating, is the last operation before preparation for sale.
3. Sections:	The section mill, following bloom reheating is the last operation before preparation for sale.
4. Flat Products (Strip):	A much more complex set of downstream processes exists than in the other products as follows.
a) Secondary rolling	to wide, thick, hot-rolled coil, some of which is sold in this condition.
b) Acid Pickling	using hydrochloric, or sulphuric acid to remove mill scale.
c) Cold Rolling	reducing flat strip to final gauge.
d) Annealing	softening the steel after the work-hardening of the cold rolling operation. Present practice is to batch anneal the coils in a multiplicity of static furnaces, or a small number of continuous strand furnaces, using natural gas.
e) Temper Rolling	to achieve final steel hardness etc.
f) Cleaning and Coating (galvanising, tinning, painting).	this is "an industry in itself" involving much complex plant on various sites.

Energy use and conservation (a) present position

1, 2, 3,	Plates, billets, sections etc.	No further comment
4,	Flat products	No further comment
	a) Secondary rolling	
	b) Acid pickling	Energy consumed is principally steam for heating the pickle baths - either by direct injection or by acid-resisting heat exchangers.
	c) Cold rolling	No comment required.
	d) Annealing	The standard batch annealing furnaces consist of a single or multiple stack of coils which are covered by an inner stainless steel cover and then by a lift-off furnace. The inner space is filled with a protective gas (usually a mixture of nitrogen and hydrogen) and the other space fired by natural gas burners, formerly coke oven gas. An annealing cycle of several hours is needed.
	e) Temper rolling	No comment required.
	f) Cleaning and coating	Most processes employ steam and electricity as a principal form of energy (eg. electrolytic cleaning) but galvanising and tinning operations also have continuous gas-fired furnaces for preheating or decarborising, the raw material, in a protective or reducing atmosphere.

(b) potential for further improvement

	b) Acid pickling	Various measures are:- better management of steam usage generally, counter-flow heating by cascade design of the liquid tanks; heating by gas in submerged acid resisting heating-coils, or by direct "submerged combustion".
*	d) Annealing	Improved burners including self-recuperative burners are now being introduced, giving air preheat of up to 500°C, the furnaces varying in temperature from 700°C to 1100°C. When continuous annealing furnaces are used, combustion air preheating is usual even where self-recuperative burners are not employed. Improved combustion control and programmed heating are being introduced.
*	f) Cleaning and coating	Radiant tube, gas-fired heating is used in some furnaces, and self-recuperative burners are being applied to these. In some cases (where a reducing atmosphere is required), convential recuperators are now being introduced.

ELECTRIC ARC FURNACE PLANT

Description of process

Steel plants based on electric arc furnace melting, as compared with the "fully integrated" plants already described, exist basically to consume the scrap existing in the U.K. and/or, to make steel qualities that are particularly suited to electric melting. Modern practice is to combine the electric arc furnace operation with continuous casting and a hot mill for wide coil, billets or sections (mini-mills configuration). Vacuum degassing is applied to some steels.

This note deals only with the arc furnace and immediately associated plant, as the other items are as described in the previous section. Reference should be made however, to the direct reduction plant producing the Fe. pellets which forms an alternative partial burden.

Energy use and conservation (a) present position

1. Due to the energy "sequestered" in the scrap charge, the total energy consumption in an arc furnace based steelworks is about one third (say 7GJ/tonne of liquid steel) of that consumed in an integrated works. There is a "macro-equation" which at present favours maximising the use of scrap in the industry overall.
2. Apart from alloy steel manufacture, the "tonnage", electric arc furnaces are large (say 125 tonnes) and of "ultra high power" input (say 100 MVA). Input is automatically controlled, for high efficiency.
3. * In some furnaces, melting is assisted by oxygen injection or by an oxy-fuel burner.
4. * For maximum energy efficiency, the furnace is used as a melt-down unit only, refining taking place in a separate vessel - sometimes in a vacuum degasser.
5. * Hot gasses, evolved from the arc furnace are extracted, cooled and cleaned.
6. * Scrap and pellets are charged cold.
7. * Parts of the furnace are water cooled.

(b) potential for further improvements

1. Advantage must be taken of electricity tariff concessions and "load management" contracts, including negotiations of better deals where possible.
2. High speed melting is important in reducing heat losses and practice must improve this further. The use of sophisticated thermal and metallurgical models, on which to base automatic control is ongoing.
3. * Oxygen and oxy-fuel can save electric power at critical times and is becoming standard. This does however, increase the volume of gasses leaving the furnace.
4. No further comment needed.

* 5, 6. Heat can be recovered from the waste gas off-take, either by a waste heat boiler, or by pre-heating the scrap. The latter is being studied and trials are in hand.

7. Evaporative cooling of parts of the furnace are being considered.

Summary of Processes and Heat Recovery Operations - continued
Finishing Processes and Specialised Processes

Annealing (Mild steel)

Description of process	Already covered, earlier in notes.
Energy - present position	" " " "
Energy - potential for further improvements	Estimated at 20% or 0.3 GJ/tonne.

Tinplate

Description of process	Thin gauge strip is cleaned and pre-heated in liquid baths, tin-coated in an electrolytic bath, and the coating fused in an electric, induction - heated furnace.
Energy - present position	No fuel-fired furnaces are involved. Energy is mainly in liquid heating and in evaporation to recover tinning salts.
Energy - potential for further improvements	Mainly in better evaporative techniques. No high temperature heat recovery.

Galvanising

Description of process	Cold strip is preheated in a reducing atmosphere in (a) a direct fired furnace (b) an indirectly heated (gas radiant tube) furnace. Coating is applied by passing through a molten zinc bath, electrically induction heated. Strip is then cooled.
Energy - present position	a) direct fired furnaces some of poor design, discharge to atmosphere at very high temperature. b) radiant tubes have no heat recovery equipment.
Energy - potential for further improvement	a) Furnace design and length to be improved, this giving better heat recovery to the stock and reducing the exit gas temperature to say 700°C. Recuperators will then be installed to reduce temperature further (air preheat only) b) Self-recuperative inserts will be installed in the radiant tubes. An overall 50% improvement, at least, is expected ie. by 1.0 GJ/tonne product.

Coating (coil-coating paint lines)

Description of process	Wide, cold-reduced coil, either plain or galvanised, (or aluminium coil) passes through precision levellers, followed by chemical treatment tanks (cleaning phosphating) which are steam heated. Primary paint is applied by a "roller coater" and the coating cured and stoved in a gas-fired oven. This is repeated, for the final paint coat, in a second coater and oven the strip being then cooled and re-coiled.

Energy - present position

Four coating lines exist in B.S.C., all of varying detailed design with energy consumption varying from 1.7 to 2.8 GJ/tonne. This is a good result, comparable with the competition, as a result ot work already done. Combustible solvent fume is produced in the ovens, which operate at about 300°C, and must be removed safely (avoiding explosive risk) but without using so much dilution air that energy efficiency is sacrificed.

In "works No. 1"

The above is achieved only by tight management and instrument control on the ovens.

In "works No. 2"

It is achieved mainly by having installed already equipment to burn the solvent fume directly back into the ovens, (subject of E.E.C. demonstration project). A waste heat boiler recovers further heat from the stock gasses.

In "works No. 3"

It is achieved by using a large external solvent incinerator, the hot gasses produced being passed through a waste heat boiler, before going to the stack or back to the oven.

Energy - potential for further improvement

a) Adopting fume incineration and/or waste heat boilers.
b) Improving standards of control and operation at all works.
c) It is theoretically possible to reduce fuel consumption to almost zero, all heat being derived from the solvent.

Electrical steels

Description of process

Hot reduced wide coil, of particular analysis to give magnetic as well as physical properties (varying silicon proportions) is annealed in a continuous roller-hearth furnace at up to 1100°C. This is followed by cold-rolling, inter-annealing and decarburising in a variety of extremely long (eg. 700 ft.) continuous furnaces, in a hydrogen atmosphere. The coil is, typically-then coated with magnesium, dried in a continuous oven and then batch annealed at very high temperature. The final process is the establishment, of a "glass" film involving further coating, stoving and flattening.

Energy - present position

This is an extremely energy-intensive process, the present figure of 5.5 GJ/tonne having been achieved by development work over the last five years. This is an average figure, some qualities using as much as 15 GJ/tonne.

The various continuous furnaces and the high temperature batch anneal furnaces (800/1100°C, and 1250°C respectively) have been mainly heated by electricity (radiant strip elements and radiant tubes).

Energy - potential for further improvement

a) Where gas firing is involved, the use of self recuperative burners has been, and is being, widely adopted, over 200 having been installed already.
b) Partial conversion from electricity to gas offers the possibility of both cost and energy savings, including the use of recuperators or S.R.B's.
c) High temperature annealing is probably the industries' most intensive, finishing process energy consumer, (up to £90/tonne) and detailed technical work is in hand to evaluate alternatives. (eg. a) gas firing b) tunnel furnaces).
d) U.K. energy performance compares with world best but it is felt that reduction of over 2GJ/tonne are possible.

Plates

Description of process

After reheating and primary rolling, to plate thickness, 80% of the output goes directly for levelling, cutting and packing, only 20% being subject to heat treatment, i.e. normalising or quenching and tempering i.e. plate production does not have extensive finishing processes as for coil and strip.

Energy - present position

Continuous reheat furnaces - before primary rolling. Usually, walking beam furnaces are used, with recuperators, giving reasonable efficiences et. 58%.
Batch Reheat Furnaces - before primary rolling. Bogie furnaces for their thick plate are used. These mostly have air recuperation to 500°C but efficiencies are relatively low (eg. 40%) due to batch processes and scheduling problems.
Normalising Furnaces - these are batch type, with protective atmosphere to avoid scaling and operate at 900°C.
Tempering Furnaces - these are direct fired and operate at about 650°C.

Energy - potential for further improvement

Reheat Furnaces

As opportune, more recuperators and self-recuperative burners will be adopted, but much potential lies in better scheduling and furnace management generally, plus improved insulation.

Heat Treatment Furnaces

Ditto, the aim being to achieve air preheats of up to 350°C.

Billets, Bars, Sections etc.

Description of process

As for places the production of billets, bars, sections and tubes has relatively few finishing processes involving the use of energy in fired furnaces. Comment is therefore restricted to the various reheat furnaces immediately before rolling to bars, sections etc. It must also be borne in mind that, in any case, the rolling of billets from blooms is being steadily replaced by the direct continuous casting of billets. Where blooms are required eg. for supplying section mills, these are increasingly continuously cast.

Energy - present position

Blooms, billets, bars sections.

Pusher type furnaces are used for re-heating blooms, ahead of billet and section mills, and walking beam furnaces for reheating billets ahead of rod and bar mills. Most are modern and have air-preheat recuperators (500°C), giving furnace efficiencies of over 62%.

Energy - potential for further improvement

Blooms, billets, bars sections.

1) Potential exists in installing more recuperators as opportune, and also be moving towards evaporatively cooled skids.
2) As for slab reheat furnaces, the option exists of installing waste heat boilers, following, or instead of, recuperators. Where there is a good demand for steam, this is a useful and fairly trouble-free alternative.
3) All the other possibilities already mentioned exist, eg. better combustion control, hot charging, furnace delay strategies etc.

Stainless steel

Description of process

Modern practice is to continuously cast most of the requirement, to slabs, this eliminating the ingot to slab rolling stage. Hot rolled coil is for some qualities picked, and shot-blasted, then directly rolled down to cold reduced gauges. For other qualities, an itial continuous annealing process is included. After cold-rolling, the coil is softened and descaled in an open, continuous gas-fired catenary furnace followed by acid pickling. As an alternative, it is softened in a hydrogen-atmosphere bright-annealing furnace, avoiding the need for de-scaling. Final properties are given by temper rolling.

Energy - present position

Until recently, initial and final "open annealing" was in simple catenary furnaces without recuperation. More recently, efficient furnaces with air recuperators have been installed, together with both gas and electric bright annealing furnaces

Energy - potential for further improvement

The re-equipping of the U.K. stainless steel works has already achieved substantial improvements but work is continuing to install more recuperators, and to adopt self-recuperative burners. Given a good work load, an improvement of 1 GJ/tonne product is readily achievable.

ENERGY CONSUMPTION AT MAJOR WORKS – SECONDARY ROLLING & FINISHING

Report for the 4 Weeks Ending 27/02/82

WORKS	SECONDARY ROLLING: CHARGED WEIGHT (KT)	NET GJ PER TONNE CHARGED WEIGHT: FUEL FOR HEATING	POWER	OTHER	TOTAL	WASTE STEAM PRODUCED	NET ENERGY CONSUMED	DIRECT ROLLED TONNAGE (KT)	CHARGED AND DIRECT ROLLED (NET GJ/T)	PRIMARY AND SECONDARY ROLLING (GJ/TCS)	FINISHING (GJ/TCS)
IRON AND STEEL MAKERS											
RAVENSCRAIG AND GARTCOSH	78	2.60	0.33	0.35	3.49	0.40	3.07	–	3.07	2.61	0.46
SCUNTHORPE WORKS	132	1.56	0.23	0.16	1.97	–	1.97	–	1.97	2.53	0.11
TEESSIDE WORKS	130	2.63	0.36	0.29	3.27	0.14	3.13	39	2.41	2.51	0.01
LLANWERN	132	2.90	0.40	0.48	3.78	0.80	3.92	–	3.82	4.70	0.70
PORT TALBOT	133	2.69	0.38	0.41	3.48	–	3.48	–	3.40	4.13	0.70
WORKINGTON	151	3.10	0.21	–	3.32	–	3.32	–	3.32	–	–
TOTAL IRON & STEEL MAKERS	619	2.47	0.3[illegible]	0.33	3.16	0.12	3.04	39	3.06	3.27	0.36
OTHER STEELMAKERS											
ROTHERHAM	48	2.45	0.41	0.29	3.15	–	3.15	–	3.15	3.20	0.30
STOCKSBRIDGE	–	–	–	–	–	–	–	–	–	2.53	0.55
TINSLEY PARK	8	2.84	0.74	–	3.58	–	3.58	–	3.58	1.91	0.24
PANTEG	–	–	–	–	–	–	–	–	–	–	6.44
SHEPCOTE LANE (SMACC)	6	4.29	0.91	0.30	5.09	–	5.09	–	5.09	1.04	7.00
STOCKSBRIDGE NO 3	–	–	–	–	–	–	–	–	–	–	–
CRAIGNEUK	6	4.43	0.26	–	4.69	–	4.69	–	4.69	1.99	1.30
RIVER DON/TICKLES	–	–	–	–	–	–	–	–	–	–	–
DARNOW	–	–	–	–	–	–	–	–	–	–	–
CLYDESDALE	–	–	–	–	–	–	–	–	–	–	–
TOTAL OTHER STEEL MAKERS	75	2.60	0.43	0.27	3.29	–	3.29	–	3.29	2.25	0.91
OTHER CO-MAKERS											
HARTLEPOOL	36	2.49	0.38	0.09	2.96	–	2.96	–	2.96	–	–
[illegible]	–	–	–	–	–	–	–	–	–	–	–
TOTAL BSC (ALL WORKS)	795	2.94	0.39	0.32	3.24	0.11	3.13	39	2.98	2.35	1.29

STATISTICAL SERVICES
25/03/82

ENERGY CONSUMPTION AT MAJOR WORKS – SUMMARY

Report for the 4 Weeks Ending 27/02/82

WORKS	Dry Coal Carbonised KT	Production: Hot Metal KT	Production: Liquid Steel KT	Coke Making	Sinter Making	Pellet Making	Iron Making	Steel Making	Concast, Rolling and Finishing	Power Generation	Boiler Plant	Other Activities	Losses	TOTAL
				Net Consumption of Energy – Net GJ per Tonne of Liquid Steel										
IRON AND STEEL MAKERS														
Ravenscraig and Gartcosh	65	118	130	3.00	2.42	–	13.33	0.60	3.16	0.93	1.27	0.30	1.49	26.31
Scunthorpe Works	103	193	227	2.35	2.09	–	11.28	0.19	2.63	0.41	0.23	0.27	0.31	19.96
Teesside Works	120	204	214	3.18	1.91	–	13.40	0.17	3.31	1.34	0.73	0.55	0.24	24.08
Llanwern	87	126	156	2.93	1.38	–	12.40	0.30	5.36	0.38	0.65	0.15	0.46	23.94
Port Talbot	116	144	171	3.38	1.73	–	11.70	0.29	4.60	0.12	0.86	0.41	0.70	23.82
Workington	–	–	–	–	–	–	–	–	–	–	–	–	–	–
TOTAL Iron & Steel Makers	494	790	909	2.93	1.89	–	12.33	0.28	3.88	0.44	0.69	0.39	0.63	23.38
OTHER STEELMAKERS														
Rotherham	–	–	120	–	–	–	–	2.13	3.39	–	0.23	0.30	–	6.08
Stocksbridge	–	–	43	–	–	–	–	2.56	2.94	–	0.55	0.23	–	6.28
Tinsley Park	–	–	44	–	–	–	–	2.03	2.07	–	0.03	0.06	–	4.74
Panteg	–	–	4	–	–	–	–	3.02	5.91	–	0.04	3.91	0.13	13.83
Shepcote Lane (Shacc)	–	–	10	–	–	–	–	2.36	8.61	–	0.13	-1.22	–	9.90
Stocksbridge No 3	–	–	2	–	–	–	–	3.74	–	–	–	–	–	3.74
Craigneuk	–	–	4	–	–	–	–	2.75	3.14	–	0.50	7.07	–	13.46
River Don/Tickles	–	–	9	–	–	–	–	3.20	–	17.16	9.43	10.54	–	40.32
Barrow	–	–	3	–	–	–	–	2.29	–	–	–	3.38	–	5.66
Clydesdale	–	–	84	–	–	–	–	2.01	–	–	–	7.02	–	9.03
TOTAL Other Steel Makers	–	–	269	–	–	–	–	2.35	3.08	0.53	0.56	1.61	0.00	8.10
OTHER COKEMAKERS														
Hartlepool	20	–	–	–	–	–	–	–	–	–	–	–	–	–
Orgreave	46	–	–	–	–	–	–	–	–	–	–	–	–	–
TOTAL BSC (ALL WORKS)	564	790	1 178	2.36	1.26	–	9.53*	0.74	4.32	0.62	0.00	1.19	0.52	21.83*

* Of which

	Iron Making	TOTAL
Ferro Furnace	0.71	0.71
Other Teesside Works	12.70	23.01

Statistical Services