THE ENERGY MANAGERS' HANDBOOK

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FOREWORD

The British Government sees the need for energy conservation as vital.

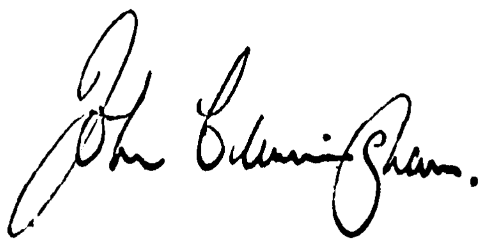
The efficient use of energy is of prime importance to all sectors of the community – and not least to the industrial sector. Energy is basic to all industrial operations and, for many firms, it can be a major factor in industrial and commercial costs. As a nation we must strive to reduce these costs and improve our profitability and competitiveness.

By using energy more efficiently and by cutting out waste, we can extend the life of our finite reserves of oil and gas which may well become scarce by the end of this century. By doing so we gain time to develop alternative sources of energy.

Everyone should make a fundamental reassessment of their energy use in all its forms.

The efficient use of energy must become part of our way of life and the Government is advocating, as a cornerstone of its industrial campaign, that all organisations should appoint an Energy Manager. This *Energy Managers' Handbook* thus comes at a most opportune moment in offering guidance and advice to those responsible for energy management.

Armed with this *Handbook* the Energy Manager will be able to carry out his task more effectively. I would expect every organisation wishing to reduce its energy costs to benefit from this valuable guide and reference source.



John Cunningham
Parliamentary Under Secretary of State,
Department of Energy

INTRODUCTION

The need to conserve our declining fuel resources, especially of oil and natural gas, is now widely accepted. By moderating our demand for energy we can usefully extend the period of time available for the safe and proper development of alternative sources. But for many sectors of industry and commerce there is a more immediate need to conserve energy in order to contain escalating costs and maintain financial viability. Large manufacturing organisations like steelworks and glassworks have long kept a watchful eye on their use of energy, but every organisation, no matter how small, needs now to follow suit.

The handbook is written for the many individuals responsible, perhaps for the first time, for the management of energy and who may not always have previous experience in this field. Unless their approach is systematic and comprehensive, much of their effort is likely to be wasted. The handbook is designed to provide, in a single publication, sufficient guidance on the principles involved, supported by check lists and illustrations, to enable readers to generate and sustain a straightforward energy conservation programme tailored to their own particular needs.

The handbook is not intended to be a text book of fuel technology and it does not deal with any topic in greater depth than is necessary to establish the basic principles, and perhaps whet the appetite. Fortunately the technology and techniques required to carry through a programme are generally well known and documented. Many sources of information were consulted in preparing the manuscript and my thanks are due to the authors not only of established books but also of the many booklets, articles and reprints on energy which have been published in recent years.

Illustrations used in the handbook are individually acknowledged. Many equipment manufacturers have been most helpful in providing photographs and other material and I am grateful not only to them but also to other friends in the equipment industry who let me have data of all sorts but whose products are not illustrated.

In compiling a handbook of this sort I have been very aware of the debt that I owe to a number of former colleagues and close friends who, over many years, helped to shape my views and who overlooked my inadequacies. To those who, for my benefit, explained complex things in simple language I am particularly grateful.

Finally my thanks are due to my publishers for their encouragement when, with some trepidation, I first approached them with the idea of yet another – but

I sincerely hope, different – book on energy, and for their cooperation since.

My wife, Jean, assisted and supported me throughout, typing the manuscript several times and providing other invaluable secretarial help, all of which I acknowledge with gratitude. Our joint efforts will, we hope, in some way help to preserve some of the precious resources which we now enjoy.

Guildford, Surrey
April 1976

Gordon Payne

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1 ENERGY CONSERVATION

1.1 The need to conserve

As we begin to appreciate that energy is vital to man's survival it is not surprising that the topic is increasingly to the fore. There are many differing views on energy resources, future requirements and costs, but several important ideas on energy seem now to be firmly established and accepted.

As reserves of fossil fuels (mainly coal, oil and natural gas) are depleted, huge amounts of new capital will be required for further and more difficult exploration and production.

As the world population increases and as underdeveloped regions of the world rightly strive for better living standards, the total demand for energy will continue to rise substantially.

Sufficient energy may not be available to meet these future demands especially if developments in nuclear energy fall behind schedule or if supplies of more conventional fuels are disrupted for political or other reasons.

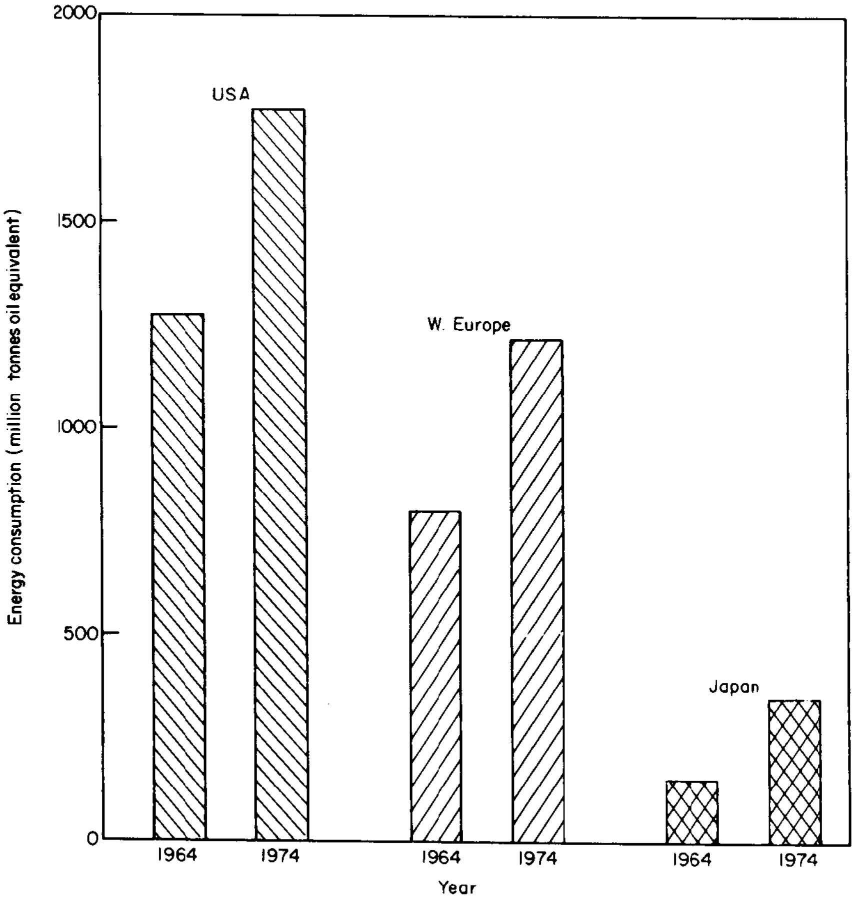
With short-term fluctuations, world prices for energy will continue to rise. New resources like North Sea oil and Alaskan oil will provide local security of supply for a period, but as world prices increase they are unlikely to provide cheap energy at any time.

Over half of the energy used by man is wasted. There is plenty of scope for improvement, though there are often practical difficulties. Improving efficiency and making fossil fuel resources last longer will give more time for the proper and safe development of nuclear power and of renewable sources of energy like solar, wind and tidal power. It may be many years before such renewable resources begin to make a significant contribution to the world's energy supply, and some may never prove to be economic on a large scale.

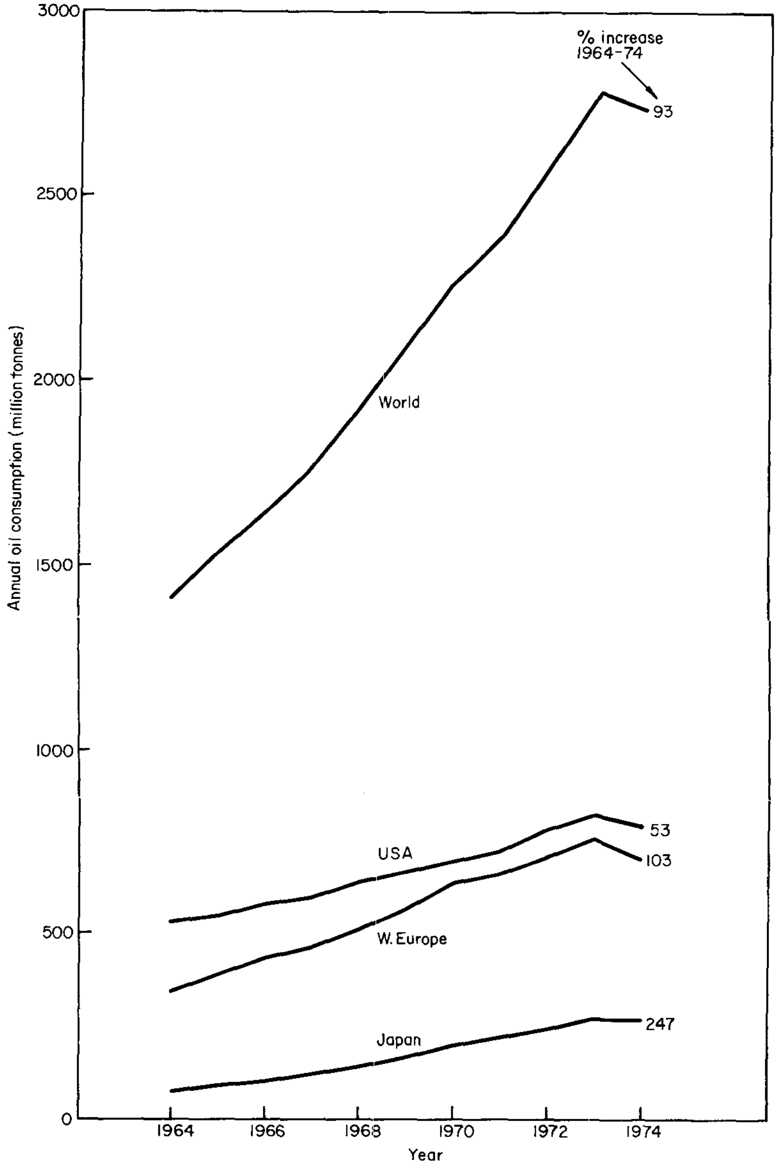
This handbook is not primarily concerned, however, with forecasts of demand and other broad economic matters, important though these are, nor with advanced new technologies. It assumes that there *is* a real need to conserve conventional energy, especially in industry and commerce, and it deals with the many practical aspects which must be considered. Industry and commerce will require little convincing of the need to conserve in order to cut their costs and to remain competitive. A comparison of their present energy prices with those of

1970 should suffice to demonstrate the rapid rise which has already occurred and, with it, a marked shift in emphasis towards operating costs of energy-using plant. The relative cost of energy and the equipment to use it efficiently needs to be carefully monitored. There has been a change in the ratio in favour of the installation of up-to-date equipment.

Industry and commerce account for an important part of the world's total consumption of energy, although, of course, effective conservation depends also



1/1 Increase in total consumption of energy for some major industrial areas, 1964–74. Based on data from the *BP statistical review of the world oil industry*, 1974.



1/2 Oil consumption, 1964–74. An indication of the need for energy conservation, and of the effect on consumption of a recession in world industrial activity.
Based on data from the *BP statistical review of the world oil industry*, 1974.

on action by many others, including governments, local authorities, major utilities and transport undertakings, as well as private individuals. But the role of industry and commerce in conservation is important not only because they have an immediate financial incentive, but also because they are in a unique position as users, suppliers and employers to influence and encourage others.

At a time when many costs are escalating and difficult to control, energy is one area where effective savings can be made. The comforting thing for the Energy Manager, or whoever is responsible for energy within an organisation, is that a great deal can be done by applying well-established principles and techniques. No white-hot new technology is required. What *is* required is dedicated and systematic application of proven ideas.

1.2 Principles of conservation

Certain over-riding principles apply to all forms of energy conservation and a grasp of these is important if worthwhile savings are to be made.

The manner and extent of *all* energy use should be challenged, including the appropriateness of the process method and the size of the plant involved. Incidental benefits or penalties should be looked for and carefully evaluated.

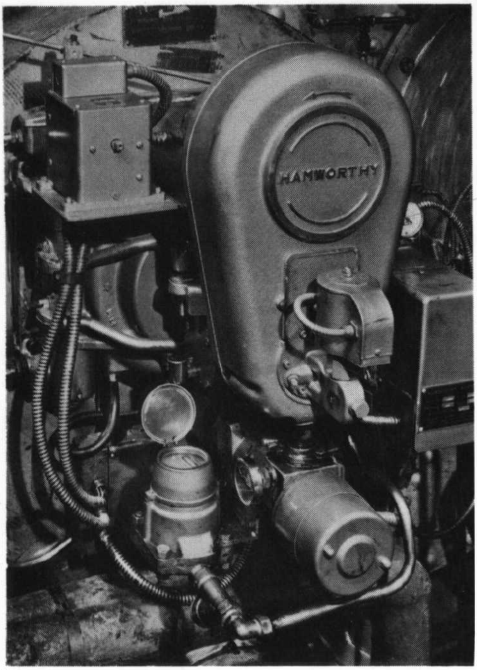
If possible, useful work should be done at each stage of temperature or pressure reduction. Most energy is lost ultimately to the outside environment in the form of heat and it should be made to do as much work as possible on the way.

Energy cannot readily be saved unless it is first measured. Consistent units and definitions must be used if measurements and comparisons are to be meaningful.

Waste heat which is recovered must be usable and an end-use must be found *before* recovery is seriously contemplated. In a normal commercial situation the value of the saving must clearly exceed the cost of recovery.

Apparent savings in energy costs should be closely examined to ensure that they have not resulted in increased costs to another department or organisation. Savings must be *real* ones.

Waste in all forms not only squanders human effort, time and materials, it also uses up energy. Reduction in waste is especially desirable where the materials involved have high intrinsic energy contents or where they require a lot of energy to process. Metals, glass, plastics, paper and refractories are examples of high-energy materials. Improvements in design which prolong the life-span of such energy-intensive materials make a valuable contribution to energy conservation.



1/3 Simple measurement of energy input to individual major items of plant is invaluable for control purposes. A small, positive-displacement oil meter fitted to the oil supply line to burners on a steam boiler.
Arkon Instruments Ltd, Cheltenham, Gloucestershire.

1.3 Preliminary considerations

Attention needs to be focused on energy use, but energy conservation cannot be considered in isolation. Due regard must be paid to other important aspects before an overall policy is developed. The following items should be included in any review.

Energy supply security.
Environmental effects of any changes.
Safety and health considerations.
Attitudes of employees at all levels.
Capital required or capital saved.
Maintenance of plant and equipment.
Emergency or standby requirements.

The *real* purpose of each piece of energy-using plant should be assessed before any change is made. A low thermal efficiency as well as a low return on investment may be quite acceptable, for example, on a rarely-used standby generator if it provides valuable 'insurance' against shut-down or serious interruption to production. A sophisticated piece of automatic plant may operate at high thermal efficiency, but it may become a serious liability if skilled labour is not available to maintain it, or if it produces some undesirable environmental or safety hazard. The use of a single grade of fuel of the lowest quality acceptable for the process, bought from a single supplier and stored in the minimum quantity may seem attractive at first sight. But such an arrangement could result in reduced bargaining power with the supplier, a risk of interruption in supply and possible environmental problems. These things need careful evaluation.

1.4 The main areas for examination

In looking for energy savings there are a number of possible areas to be considered and the following are used in later sections of this handbook.

Management of energy.

Delivery, storage and handling of fuels.

Boilers.

Furnaces.

Heat distribution and utilisation.

Industrial space heating.

Electricity.

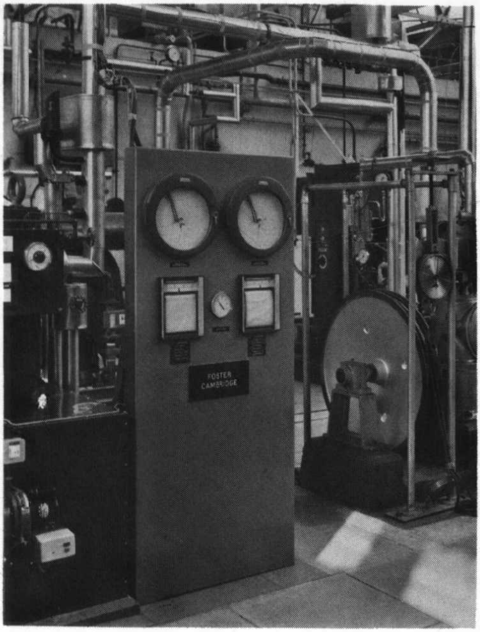
Services.

Road transport.

In each section the main text deals with the principles involved and provides background facts and figures. It is followed by a summarising check list to assist the reader in identifying energy-saving opportunities in his own organisation and to help him to develop a cohesive energy conservation plan.

1.5 Measurement

Many organisations spend large sums of money on fuel and practically nothing on instruments to measure and control. Without the measurement of energy input and output, full control is impossible. Measurements should be reliable and accurate, but no more accurate than necessary to do the job and, in the initial stages of a programme, even approximate measurements are useful. The equipment needed to measure energy and to control it is fairly straightforward. For all equipment there is great merit in simplicity and robustness.



1/4 A college steam laboratory where the value of measurement and control in attaining higher thermal efficiency are demonstrated to students in a practical way. Clear-dial indicators give direct readings at important points throughout the system, and circular recorders and 6-point strip charts provide continuous permanent records of pressure, temperature, steam flow and flue gas composition. Thermal insulation has not been neglected and a unit for determining insulation efficiency is also provided.
Foster Cambridge Limited, Huntingdon, Cambridgeshire.

Permanently installed instruments should be used for all larger plant on which frequent or continuous measurements are required. They may be used merely to indicate, or to control and record. The instruments should be regarded as an integral part of the plant and should be of high quality. They should be carefully installed to protect them from dirt and damage and to facilitate maintenance. The principal measurements made are usually of the oxygen and carbon dioxide levels in flue gases, temperatures, pressures and flow rates.

Portable test equipment may be used to take measurements where fixed instrumentation cannot be justified, for situations where permanent instruments would be vulnerable to damage and also for *ad hoc* investigations and tests. Large numbers of 'spot' measurements to predetermined schedules can more readily be taken if pipes and ducts are permanently fitted with suitable test points or plugs. Although accuracy is sometimes sacrificed, a good range of test instruments is available to make the same measurements as permanently installed instruments. Portable instruments should be robust and should preferably be used and maintained by one person only. A selection of test instruments is described in Appendix B. For every type of measurement it is essential that the method used should ensure that the measurement is truly representative, otherwise the results

1/5 Periodic checks of combustion plant performance can be carried out fairly easily using simple indicators to measure the carbon dioxide content of the flue gases, and by measuring temperatures and smoke levels. All the instruments required can be included in a small portable test kit.
Shawcity Ltd, Wantage, Oxfordshire.

will be worthless. Gas sampling requires particular care if erroneous results are not to be obtained.

1.6 Efficiency

In connection with energy the term 'efficiency' should generally be used in its strict scientific sense, i.e. the percentage of energy supplied which is usefully used in any instance. The conditions under which thermal efficiency is determined must always be clearly stated or the standard or test code quoted. In particular, the heating value of any fuel must always be defined as the gross or net calorific value (CV) at constant volume or pressure. The gross or upper value is that obtained by cooling the products of combustion to a defined ambient temperature and condensing any water vapour which they contain. The net or lower calorific value excludes the heat obtained by condensing the water vapour. Thus combustion plant appears more efficient when net CV values are used in calculations rather than gross CV values. Care is needed in comparing the performance of plant fired with fuels of differing hydrogen content and therefore differing water vapour content in their flue gases. Care must also be exercised in using efficiency values for particular items of plant based on full-load tests under ideal conditions. The average practical efficiency of a steam boiler, for example, may be much lower than its tested efficiency when losses from blowdown and variable-load operation are taken into account. Efficiency of heat utilisation is as important as efficiency of heat production, and overall efficiency, which is what *really* matters, is the product of the separate efficiencies in each step of the heat production, distribution and utilisation chain. It follows that if a step can be eliminated or made more efficient the overall efficiency is improved proportionately.