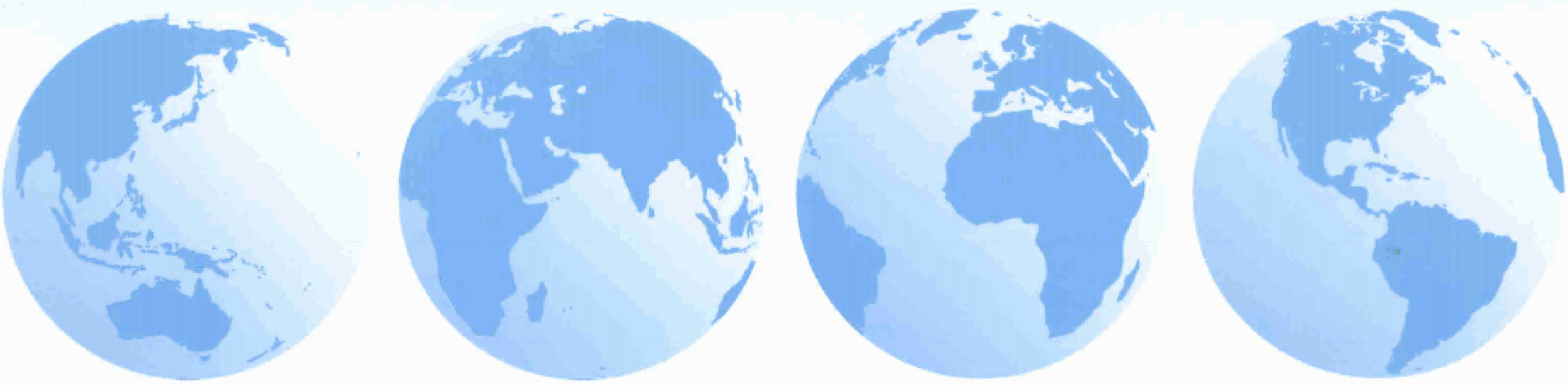
Managing energy efficiently



Shell Briefing Service

Managing energy efficiently

The modern industrialised world is dependent on energy which has been the power behind economic growth and prosperity. Since the middle of last century, world demand for commercial primary energy has increased eightyfold. In 1990, it reached 169 million bdoe*, more than four-fifths of which were for conventional fossil fuels – oil, natural gas and coal. Around half of this energy is consumed in OECD countries where, over the past decade, demand has remained constant or risen only slowly. This is due to a shift away from energy intensive industries and to an increase in energy conservation measures.

*barrels a day of oil equivalent

Although there has been considerable focus on energy efficiency in these countries, studies have shown that there is potential for further improvements. Recent studies suggest that average efficiency of energy use could be improved by 10-25% if today's best practices were adopted: as these practices improve, as much again could be saved in the next twenty years.

Energy demand is growing fastest in the developing world, where population growth is high and countries have embarked on the energy-intensive processes of industrialisation, urbanisation and motorisation. In twenty years, total energy demand in developing countries could be close to that of the developed world.

The need to use energy efficiently is therefore paramount. Although recoverable fossil fuels are thought to be equal to some ten billion† barrels of oil – sufficient to last 170 years at present rates of consumption – they nevertheless constitute a finite resource. Moreover, there is increasing concern at the environmental consequences of burning fossil fuels. Using them efficiently is a rapid and effective means of responding to environmental problems such as the possible augmented greenhouse effect.

†billion equals 10^{12}

This Shell Briefing Service is about energy efficiency in industry. Although largely based on the experience of energy management in the international oil industry, the content is directed at small and medium-sized industrial operations, especially in developing countries. It forms an introduction to energy auditing to demonstrate how industrial management can start to explore the benefits of using energy more efficiently. It shows that energy efficiency is not only a means of improving commercial competitiveness and economic performance, but can also help to reduce the environmental impact of commercial operations.

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This Shell Briefing Service is based on a report, *'Climate Change and Energy Efficiency in Industry'* produced by The International Petroleum Industry Environmental Conservation Association (IPIECA) in co-operation with the United Nations Environment Programme (UNEP) and UNEP's Industry and Environment Office (IEO). Copies of the report can be obtained at £5.00 a copy from:

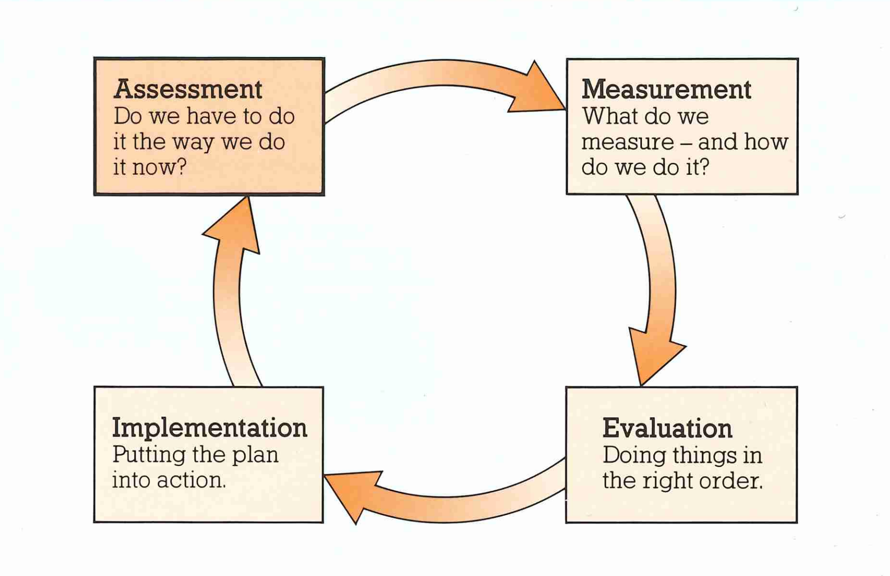
IPIECA, Monmouth House (2nd floor), 87-93 Westbourne Grove, London W2 4UL, England.

Energy planning – assessment

A well-conceived and properly executed energy plan can be more beneficial than other widely publicised techniques for improving efficiency. While the concepts involved are simple, their implementation requires careful consideration of all aspects of a plant's operation. This Shell Briefing Service describes the basic issues likely to confront an energy co-ordinator and suggests ways of tackling the tasks involved. The issues can be divided into four main areas: assessment, measurement, implementation and evaluation. As Figure 1 shows, energy planning is not a once-off activity that can be carried out and then forgotten. It is a continuous process which should involve a series of improvements, each of which increases the efficiency with which the industry concerned uses its energy.

The first step towards improving fuel use efficiency and reducing energy costs is to assess the options. A critical examination of how electricity is used, which steam and condensate or compressed air systems are in place and how heating, ventilation and air conditioning function, can demonstrate where savings can be made. Energy can be saved by recovering waste heat or by operating a cogeneration scheme. These and other areas which merit particular attention in an energy plan are described in detail below.

Figure 1 **The energy efficiency plan**



Using electrical energy

At some sites, electricity costs are disproportionately high – electricity accounts for much of the cost of energy consumed but only a small part of the total energy used. Information is needed not only on the amount of electricity consumed but also on the prices charged by the supplier (if the electricity is not generated on site). Many electricity tariffs include a maximum demand charge in order to promote a steady demand on the supplier's distribution system by penalising peak loads of short duration. Such charges can be minimised by switching off non-essential electrical plant – 'loadshedding' – at times of high electricity demand. (Such plant should be listed during the planning phase of the study.) Some industrial sites, where the maximum demand charge forms a significant proportion of electricity costs, have automatic electrical loadshedding.

Maximum demand charge may also be reduced by increasing the proportion of electricity used at night, thus taking advantage of cheaper, off-peak rates. Time clock settings should be checked to ensure that these are the same as the off-peak start and finish times as published in the tariff.

The power factor is a useful index of how well electrical equipment is matched to supply. It can be measured with a portable power factor indicator. A low power factor can be improved by installing capacitors. These have no effect on actual power consumption. The optimal power factor will depend on the relation between capacitor cost and demand charge savings.

If electricity costs are high as a result of the demands of electric motors, it may be worthwhile using variable speed motor drives or more efficient electric motors. Electric motor speed can be varied without appreciable loss of efficiency by use of a variable frequency inverter. It also provides a 'soft start', in which speed is increased and the load applied gradually. Since an inverter presents to the supply a power factor of 0.96 at all loads and speeds, power factor correction capacitors are not needed. In new installations, part of the cost of the inverter can be offset against the savings made

Case history

A hypermarket in Perpignan, France, changed from an artificial lighting system to one which combines natural and artificial light. More than 100 transparent domes were installed on the roof and the ceiling was painted a light, reflective colour.

This use of solar energy resulted in savings in both lighting and heating. Lighting costs were reduced by about a third and heating costs by about five per cent. Because maximum energy savings are obtained in the summer, when electricity for industrial users in France is cheap, the pay-back period is relatively long – about eight years.

Thirty out of France's 600 hypermarkets now use a similar system, which would be suitable for many industrial and commercial buildings.

by omitting starters and power factor correction capacitors.

Sites that have steam available could consider converting from electric motors to steam turbines – particularly if the steam is generated at one pressure and has to be let down to a lower pressure for use in equipment such as heat exchangers. If the steam pressure is reduced through a let-down valve, there will be an energy loss that can be recovered.

Fans, pumps and vacuum systems are designed such that they rarely run at full capacity, and there are long periods when there is less than maximum flow. The reduction in flow is usually achieved by the use of dampers, throttle valves or bypass systems, all of which are wasteful of energy.

In a pump, instead of using a throttle valve, flow can be reduced by decreasing the pump speed, thus reducing power consumption of the motor. Similarly, the power consumption of fans can be substantially reduced by slowing them down to reduce air flow instead of closing inlet or outlet dampers.

Lighting can account for more than half electrical energy usage in buildings. Energy can be saved by installing more efficient lighting and using automatic lighting control systems (Figure 2). Replacing lighting can not only reduce costs but also improve illumination. There are systems which continually monitor illumination levels in a building and automatically switch lighting off when natural daylight makes it unnecessary; lighting can also be switched on automatically as daylight fades. Automatic lighting systems have programming options that can be applied individually or in combination to ensure that energy is saved and that the required lighting levels are reached.

Boilers and furnaces

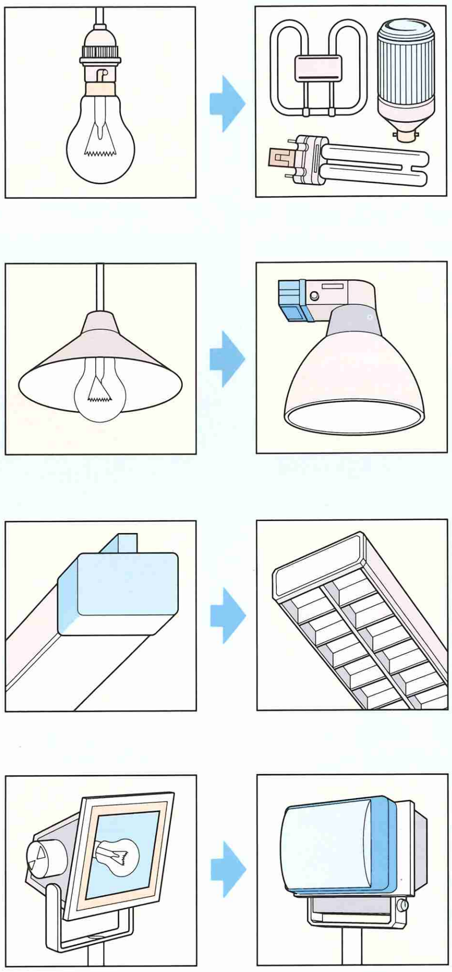
On an industrial site, one of the largest energy consumers is normally a boiler or furnace using fossil fuel. If there is a choice between energy sources, (ie, liquid fuel, natural gas, steam, electricity) their relative prices should be reviewed regularly to ensure that the most economic is used. One advantage of natural gas over other fossil fuels is that its use results in less fouling of the boiler or furnace surfaces and more efficient firing. A disadvantage may be that conversion from other fuels to natural gas will require adjustment to furnace geometry and new burners. When coal is used, the optimum excess air rate is higher than for either fuel oil or natural gas.

Steam and condensate systems

The main points to consider when studying the energy efficiency of steam and condensate systems are:

- correct (most economic) thickness of insulation,
- prevention of steam leaks,
- suitability and correct operation of steam traps,
- return of a high percentage of steam output to the boiler as condensate, and
- use of waste heat in place of steam.

Figure 2 **Improving lighting**



What to look for	How you benefit
Ordinary filament light bulbs can be replaced with compact fluorescent lamps. Alternatively, use low-voltage tungsten halogen lighting, or metal halide discharge lighting.	Immediate energy cost saving of 75%, plus reduced maintenance through much longer lamp life. Overall lighting cost can be cut by half, with low capital outlay.
Replace mercury lights, old 125-watt fluorescent fittings and high-wattage light bulbs with either high-pressure sodium or modern fluorescent lighting.	Sodium lighting gives satisfactory colour rendering and is very energy effective. High-frequency electronic lighting gives energy costs almost as low as sodium lighting, plus excellent colour rendering.
Old 40- and 125-watt fluorescent fittings, warm-tone fluorescent lamps and those with opal diffusers can be replaced with prismatic lens fittings using power-saving 'triphosphor' lamps.	Energy savings of 30%-45% are commonly achieved, with much improved lighting quality. Benefits include easy starting, good colour rendering and elimination of glare, flicker and hum.
High-wattage filament lamps and tungsten halogen floodlights can be replaced with high-pressure sodium lamps or mercury discharge lighting.	Energy savings of 60%-80% can be achieved and the quality of lighting can be greatly improved.

Case history

A Peruvian paper manufacturer in Lima installed an automatic control package on its 750 kW boiler which was expected to pay for itself within five years.

The firm analysed the performance of the boiler during an energy planning exercise. It found that the boiler was operating at 74% combustion efficiency and had 12% excess oxygen in its flue gases.

By installing a commercial boiler control package, efficiency was increased to 86% and excess oxygen reduced to 1.8% (and subsequently 1.5%) at high loads. The new controller monitors boiler performance continuously and adjusts the air/fuel ratio to optimise combustion.

Regular maintenance and cleaning of steam traps is a particularly low-cost high-payback activity.

Waste heat recovery

Energy is wasted if it passes straight up the flue or out of the window as heat rather than being put to any use. Recovering this heat is one of the major goals of any large energy conservation scheme. Where conditions are right, waste heat can be diverted to play a role elsewhere in industrial production, leading to savings of as much as 80%.

Heat can only be recovered if:

- there is enough to make recovery worthwhile,
- there is a use to which it can be put,
- that use is not too distant,
- the time at which the heat is wasted and the time at which it can be put to another use must be close enough not to require the installation of expensive long-term heat storage.

There are many ways of recovering heat. One of the most common is to use stationary heat exchangers, of which many types exist.

Another form of heat exchanger is the heat pump, which can extract heat from a cool object – typically a body of water such as a pond or the air itself – and transfer it elsewhere. In the process the source is cooled, and the place to where the heat is transferred is heated. As the name implies, the heat has to be 'pumped' from one place to the other, and energy is expended in the process. Normally, however, considerably more heat is transferred than is used by the pump itself.

Another option is the thermal wheel, which consists of a large rotating wheel made of a honeycomb metal or ceramic matrix which spins in two gas ducts. The first carries what would have been waste heat. The rotation of the wheel transfers heat absorbed in the honeycomb to cooler gas flowing through a second duct. As much as 90% of waste heat can be recovered with this device.

Cogeneration

Many industrial concerns generate steam on site for heating but import electricity from the local grid. A more efficient way of producing both heat and electricity is by cogeneration – the simultaneous utilisation of heat and power from a single thermodynamic cycle (Figure 3). For example, in a 'steam-topping cycle' cogeneration system, a boiler is used to produce steam at high pressure which is piped to a turbine driving a generator. The electricity produced is used by the plant and any surplus is sold. Since the steam from the turbine retains much of its energy, it can be used again for heating or other applications.

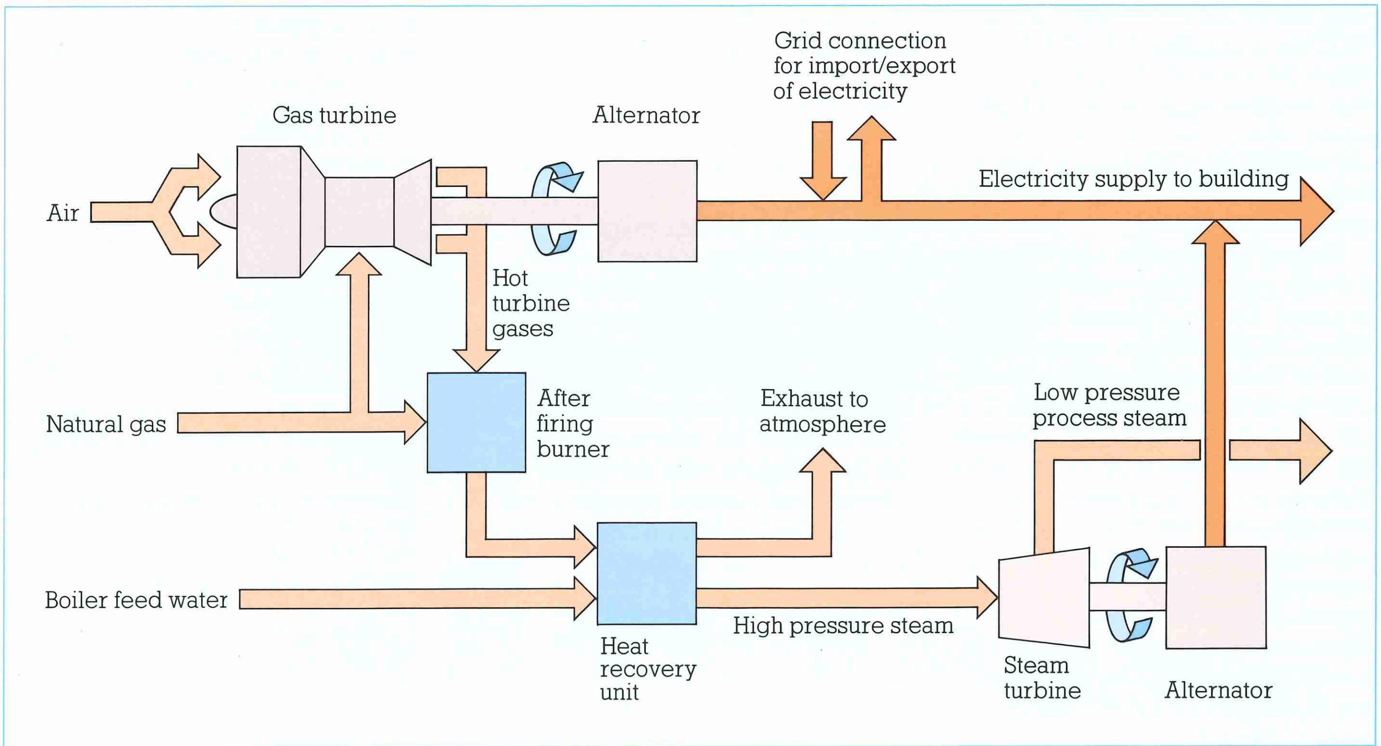
Energy-intensive industries that need both electricity and heat at moderate to high temperatures can

Case history

A heat pump system extracting energy from sea water was put into operation in a hotel in the Black Sea resort of Yalta, in the former Soviet Union. The plant is designed to heat the hotel itself, its water supply and swimming pool, and to power the air-conditioning system in the summer.

Three heat pumps are used to heat water on the output side to a maximum temperature of 65°C. The plant consumes 70 kWh of electric energy to produce the equivalent of about 280 kWh of heat, providing a four-fold energy gain. Over a year, the plant requires 1.9 million kWh of electric energy. As a result of its installation, around 840 tonnes of liquid fuel are saved annually. The pay-back period is estimated at six years.

Figure 3 **Cogeneration**



benefit from cogeneration which is also used increasingly in institutions such as schools, hospitals and hotels.

Electricity can be generated via gas turbines and diesel engines as well as steam turbines. The choice depends on the relative amounts of process heat and electricity needed, and on the uses to which the process heat is to be put. The power-to-heat ratio is lowest for the steam turbine and highest for the diesel engine. When using a gas turbine, the hot exhaust gases from the turbine can be used directly for process heating and drying, or as highly preheated combustion air in boilers or furnaces.

Compressed air systems

Since most industrial sites need compressed air, energy can be saved both by heat recovery and by using better compressor control systems. It has been estimated that a 75 kW compressor can be used to generate 65 kW of heat for space heating and water heating – in addition, of course, to fulfilling its compression requirements. In an oil-injected screw compressor, about 80% of power is lost to the cooling oil injected into the compression chamber, and 15% to water in the after cooler which reduces the temperature of the output air to a usable level. Oil-free compressors, which use water rather than oil as the primary cooling medium, run hotter than the lubricated types, thus providing recovered heat at 90°C as compared with 60°C for lubricated screw compressors. If the compressor is driven by a gas or diesel engine, heat can also be recovered from the engine water jacket, oil system, exhaust manifold and exhaust gases.

Energy savings can also be made by using on/off load running control systems. Control systems normally lower the compressor casing pressure to between one and two bars during compressor idling, thus giving shaft power savings. Systems are now available which reduce the compressor casing pressure to atmospheric when running off load, enabling the motor to use 15% rather than 30-60% of the on-load power. Some systems also shut down the compressor and hold it ready for restarting if it runs in the off-load mode for longer than a pre-set period.

Heating, ventilation and air conditioning

Industries, particularly the service industries, spend and waste energy in similar ways to house owners. There are more solutions open to industry, however. Introducing shift work, for example, is one way of avoiding expensive cooling and heating cycles required in large buildings used only on a part-time basis.

Similarly, industrial buildings on exposed sites – unlike domestic houses – can often be easily protected by planting windbreaks or constructing buildings, such as covered car parks that do not require heating, to the lee of the wind. Space heating may be supplemented from heat recovery systems, particularly where ducted warm air is used for the heating system.

Energy coordinators need to look carefully at total expenditure on space heating and air conditioning which, like lighting, may add substantially to overall energy expenditure. One option may be to install thermostats that turn heating systems on and off when, for example, movement is detected or not detected in a building.

Transport

In many organisations involved with distribution and storage, road transport accounts for as much as 60% of total energy consumption. The energy efficiency of vehicles can be improved by, for instance, changing driving techniques and vehicle technology, improving route allocation and driver training.

Although training schemes are of great value in improving driving techniques, bad habits tend to reappear after a certain time. On-board vehicle computers are now sometimes used to monitor when the vehicle is operating within the ideal engine speed range for greatest efficiency and economy. Any cases of low efficiency can be investigated with the driver to identify any unusual aspects of the trip and bad driving habits can be pinpointed and rectified.

Alternative energy

In addition to energy efficiency savings at point of use, alternative energy sources such as solar, wind, geothermal, biogas, biomass and wastes are worth considering. In developed countries, these energy sources have been examined extensively. For instance, wind turbines are now used commercially in countries such as Denmark, the Netherlands and the USA.

In developing countries, alternative fuels, particularly biogas and biomass, are widely used. Fuelwood and charcoal are used in many industries, including brick making, pottery manufacture, brewing and even cement and lime production. Waste materials are an important fuel supplement. Agricultural wastes (eg, straw, corn cobs, rice hulls and biogas from sugar cane), which are common sources of domestic energy, can also be used industrially, often after initial processing to convert them to other fuel forms such as producer gas. Experimental versions of tractors, fishing boats, lorries and sawmills have all been successfully run on producer gas generated from agricultural waste.

Case history

A company producing animal feeds in Cumbria, England, installed a 200 kW wind turbine to generate electricity for its heavy machinery.

The turbine is controlled by a computer that automatically reduces the revolution rate of the 12-metre blades if generation rises above 250 kW – reached only in extremely windy conditions. The wind-powered system is connected to the national electricity supply. When the wind drops, the computer ensures an even flow of electricity by drawing power from the grid. When output exceeds demand, power is fed back into the grid at a profit.

In its first year, the turbine generated a total of 428 000 kWh and, with refinement of the computer program controlling the turbine, generation could rise to 450 000 kWh a year. The turbine's life expectancy is 25 years, and pay-back is likely to be in less than six.

Encouraged by the success of the 200 kW turbine, the company applied for planning permission for a 400 kW model. The combined output from these two turbines would supply nearly all the company's electricity demand, thus saving the emission of some 75 tonnes of carbon dioxide a year.

Measurement

Once options have been assessed, the next stage in preparing an industrial energy plan is to analyse existing energy usage. A company must understand in detail how it is using – and, possibly, wasting – its energy. Without this knowledge, energy users cannot judge whether their performance is good or bad. Attempts to save energy will be haphazard, and may target relatively unimportant aspects of the firm's energy economy while leaving untouched those areas where major energy wastage is occurring.

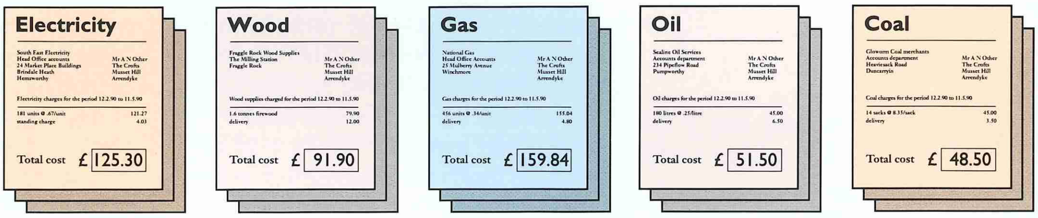
Inevitably, a study of energy use involves much meticulous measurement. However, the study itself should be simple and easy to understand, and preferably should be made compatible with existing information and control systems. Furthermore, it should provide energy use data in units that people can understand so that they can make comparisons easily.

The energy use study will balance total energy inputs with energy use, and must identify all the energy streams in a facility. By qualifying how much energy is used in which process and in which department, the study will make it possible to build up an overall picture of the way energy and fuel are used in an industry. This will help identify areas where energy is being wasted and where scope for improvement exists.

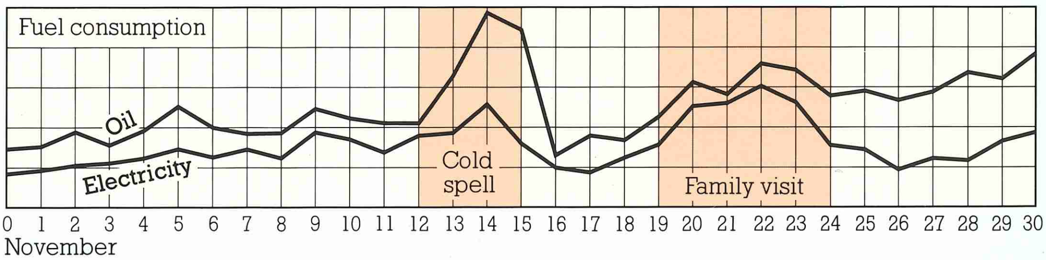
The four basic stages in preparing an energy assessment for a domestic home (Figure 4) are equally applicable in industrial energy planning. Within an

Figure 4 **Energy assessment in the home**

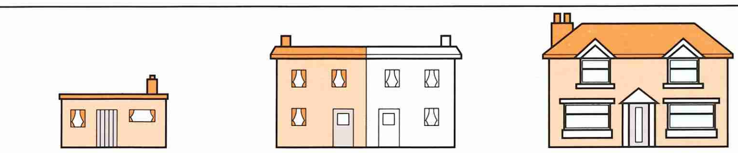
Add up a year's fuel bills



Plot daily fuel use

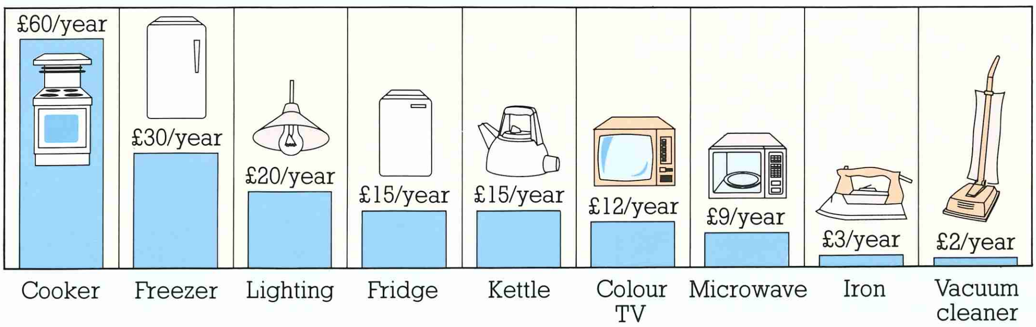


Compare energy use with standards for heating



	Single storey house	Semi-detached house	Detached house
No insulation:	11 100 kWh/year	13 500 kWh/year	19 400 kWh/year
Loft insulation:	8700 kWh/year	10 800 kWh/year	16 000 kWh/year
Loft and wall insulation:	7080 kWh/year	8460 kWh/year	12 000 kWh/year

Compare energy use with standards for appliances



Note: values are only representative and vary from country to country.

industrial environment, the process of analysing energy use may not be quite as simple, but the same principles apply. The type of analysis to be performed will depend on:

- the function and type of industry,
- the level of detail needed in the final plan,
- the potential and magnitude of cost reduction desired.

The energy efficiency plan

The main objective of an energy efficiency plan is to determine ways to reduce energy consumption per unit of product output or to lower operating costs. There are two basic types of energy efficiency plan: the preliminary and the detailed.

The preliminary plan, which is done relatively quickly, focuses on the major energy supplies and demands that account for at least 70% of total energy requirements. It can be an effective method of identifying low cost/no cost 'housekeeping' items which, if promptly addressed, could provide immediate benefits.

The detailed plan goes beyond quantitative estimates regarding costs and savings. It includes engineering recommendations and well-defined projects and priorities, covering approximately 95% of the energy utilised in the plant. From it, a long-range energy plan can be drawn up.

A detailed questionnaire about the sources, control and uses of energy within the organisation should be prepared and used in both types of plan (Figure 5).

The prime targets for measurements are most often:

- temperatures,
- pressures,
- gas composition,
- fuel consumption (oil, gas and coal),
- electricity,
- flow rates for water, air and steam.

A wide variety of techniques and equipment is available for making these measurements. They range from simple visual or aural observations through to sophisticated electronic-sensing and measuring devices.

For example, an energy efficiency plan for an industrial boiler requires several key measurements to be taken. A knowledge of the type, quantity and calorific value of the fuel used is essential. The temperature of any liquid fuel should be measured. Data regarding excess air levels or the amount of carbon monoxide contained in the flue gas, together with air inlet temperature and flue gas outlet temperature, need to be ascertained. Typical draught readings on the furnace or boiler outlet should be taken since they are required for control.

The duty or load required of the boiler must be noted ie, boiler feed

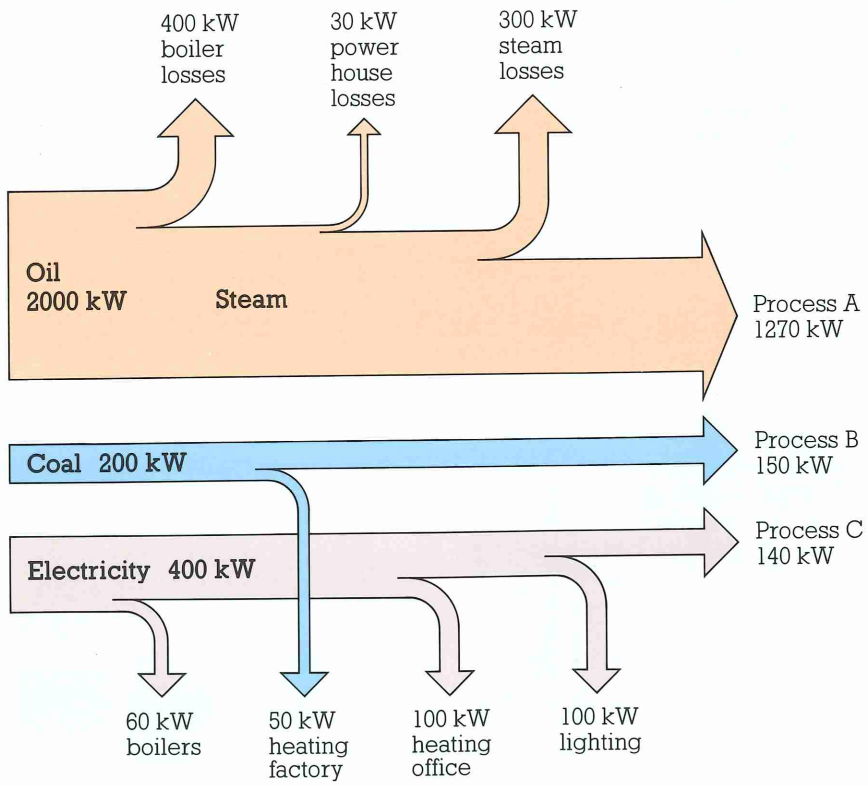
Figure 5 **Energy questionnaire**

Answers to the following can put potential energy savings into context.

1. What proportion is your total energy cost as a percentage of:
   - turnover?
   - manufacturing cost?
   - profit?
2. Have the percentages changed over the past three years?
3. Did you achieve any energy savings in the past year? If so, how were the savings made? What was saved? What did it cost to make them?
4. What expenditure is planned for future energy purchases – say the next five years – and how will they affect your profitability?
5. Who monitors your organisation's energy purchases, consumption and use?
6. Who is this person accountable to?
7. What is your present total energy cost?
8. What is the energy cost per unit of heat? (note: it helps to use consistent heat units throughout)
9. Do you know how much fuel is used in each:
   - department
   - process unit (for example, furnace, boiler, vehicle)?
10. How are your total energy costs split between lighting, power, space heating, transportation?

Figure 6 **Energy use and losses**

A Sankey diagram helps to pinpoint those areas where losses are particularly high, and where considerable savings could be made.



water temperature and how much steam is being produced, and at what pressure and temperature. From these data, the theoretical energy release of the fuel input can be calculated. The energy required to raise steam corresponding to the boiler load, at the known pressure and temperature from the measured boiler feed water conditions, can also be calculated. The difference between this figure and the fuel's theoretical energy release represents the boiler losses and allows the boiler efficiency to be calculated.

As energy consumption is also related to a production figure, production should be expressed in terms of energy consumed per unit of production. In the case of the boiler, for example, this could be kWh/kg for 40-bar superheated steam.

Data must be collected over a period of time to identify historical patterns. A graph showing current and past specific energy usage will give an insight into energy consumption trends.

Monitoring energy consumption

A Sankey diagram can also be used to help account for energy use and losses in a plant which, in turn, can be accompanied by actions required for reducing energy consumption (Figure 6). By plotting specific energy consumption against product output based on a large set of readings and measurements, it may be possible to select a best set of figures to use as a target for future output or to optimise the process with respect to energy use. Comparison of specific energy consumption with that of similar plants will also help to fix targets.

A process flow diagram with energy consumption in each operation can also be made. This indicates the level of energy consumption in different operations, and can thus be used to locate areas of high energy consumption, high costs and savings potential.

With all this information to hand, the next step is to display all the possible options together with the savings each option could produce. It will then become possible to assign priorities to each option, based on its cost/benefit ratio.

Evaluation

Before the data on energy usage collected in the measurement stage is evaluated, product waste should be examined and the energy gap calculated.

Energy savings can be made in one of two ways: by reducing the amount of defective or waste products that are manufactured; or by reducing the amount of energy that is supplied but is not usefully employed.

The easiest way to save energy is to stop making products that are never used. Each defective item produced consumes the same amount of energy as an item that is properly manufactured and eventually sold. Eliminating this waste will save energy and reduce material and manpower costs, thus generally increasing business efficiency. In this context, 'product' means not only an item of manufacture but also, for example, an unnecessary journey for a transport firm or a wasted mailing shot for a direct order company.

The theoretical amount of energy needed to carry out a process or to manufacture a product should be compared with the energy that is consumed in practice. Where theoretical and practical figures are very close, there is little point in trying to make savings, regardless of how large the current energy expenditure. Where the gap is large, however, there is always scope for savings, for example by installing insulation and heat recovery equipment and improving energy control systems.

The evaluation process by which an energy usage study is converted into an energy plan involves four stages:

- Convert the raw data on energy usage into a series of discrete actions, which together form the essence of the plan.
- Calculate the cost/benefit ratio of each action.
- Draw up a list of priorities which clearly indicates the most cost-effective actions.
- Weld these priority actions together to form a plan with targets – specifying how much energy is to be saved and by what date – assigned to each action.

Priorities are set by assessing both the technical feasibility and the economic attractiveness of the available options. It matters little how attractive an option is financially if it is technically impossible to implement. Sometimes, of course, economically attractive options have to be foregone because they involve hidden costs – such as the need to close a plant for six weeks in order to replace a furnace. In such a case, the cost of lost production may far outweigh the value of possible energy savings over many years. The only solution is then to wait until the plant has to be shut down for some other reason.

Case history

In a UK cement company, energy represented 40% of the price of the finished product and was the company's largest directly controllable cost. It was decided to reduce energy consumption by making a detailed study of energy use in the processing plant.

Meters were installed on each piece of equipment to monitor variables such as the ratio of cheap rate to ordinary rate electricity and the number of hours for which equipment ran. The amount of energy used by each machine to produce a tonne of cement could then be deduced. Energy monitoring also showed up any excess use of equipment, as well as machinery or working practices which were using energy inefficiently.

Plans were then drawn up to make the most energy-efficient use of machinery throughout the plant and, to achieve this, targets were set for energy consumption levels on individual pieces of machinery. Continuous monitoring of equipment allowed energy consumption to be kept within the company's targets.

Only four months after this monitoring system was introduced, electricity costs were reduced by 12% per unit of output.

The cost/benefit ratio is easily calculated for most energy-saving operations (Figure 7). Low cost/benefit ratios generally involve small investments. The first actions to implement when saving energy are those that are quick and cheap: stopping leaks, tuning burners and educating staff to save energy. Such projects should receive the highest priority. One example is shown in Figure 8.

High cost/benefit ratio activities normally involve substantial capital expenditure, for example to replace boilers, purchase new vehicles or electric motors, and install modern lighting systems. Such activities require more detailed analysis, as capital is normally borrowed to finance them. Discounted cash flow analysis will be needed to investigate the economic viability of such projects.

Once cost/benefit ratios have been calculated, a list of actions can be presented to management in order of priority and with estimates of the savings that are to be expected, the capital cost and the estimated payback period. Management should then allocate target dates for the completion of each project, and devise systems of monitoring and review to ensure that progress is maintained and savings achieved on time.

Case history

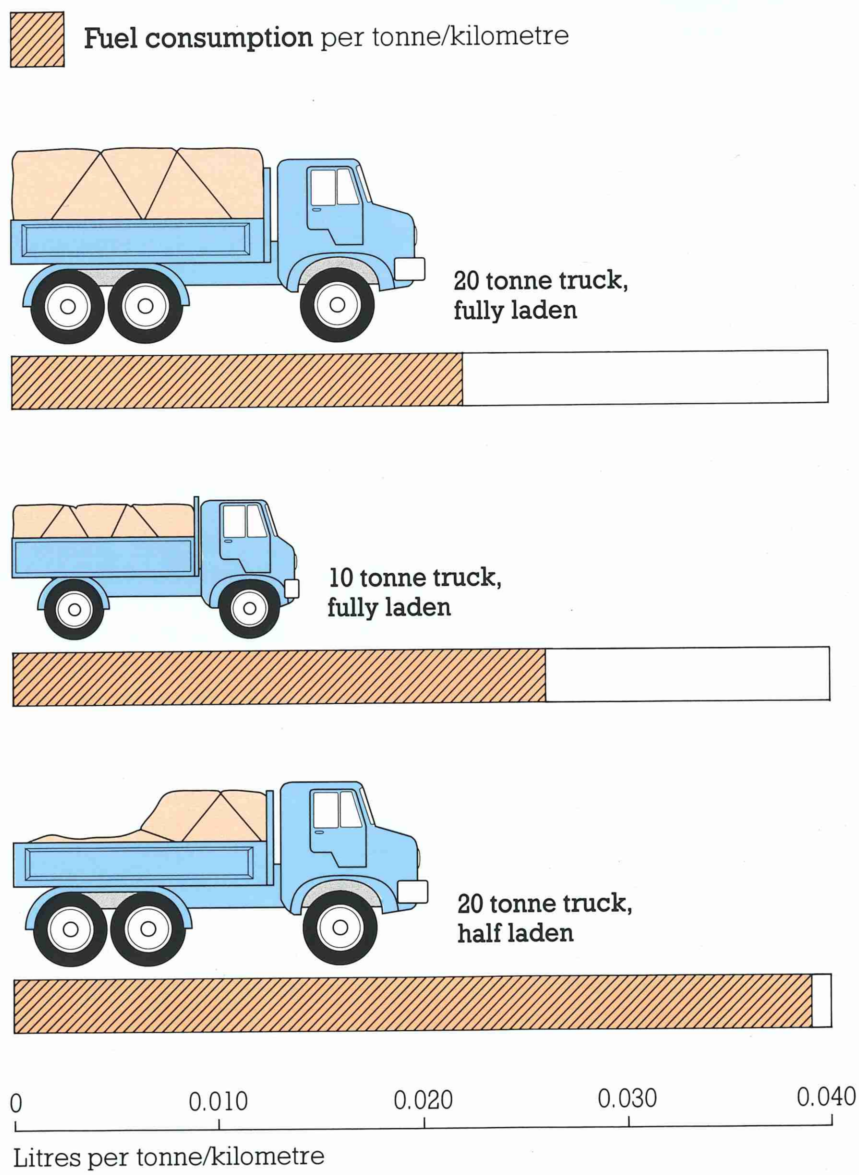
For a total outlay of less than £50 000, a nitrile rubber plant saved about £150 000 a year in energy costs by reducing consumption in several operations. The steam distribution system was simplified by cutting the number of steam pressure reducers and relief valves, and establishing a single steam main supply in place of the former dual system.

Temperature in the coagulation and washing stages of the process was reduced; fan speeds, particularly of the fluidised bed fans, were lowered to minimum levels, and thermostats were installed in the heated warehouse. Personnel were given thermal underwear so that space heating could be reduced, and were instructed in energy conservation practices, such as turning off steam, water and electricity on units when not needed, mending steam leaks promptly, and regularly servicing all steam traps.

Figure 7 **Cost/benefit ratios**

Low (favourable)	**Medium**	**High** (unfavourable)
Improve maintenance • stop leaks • check meters	Modest equipment renewal • new control systems	Install new burners and boilers
Improve procedures • tune burners • control excess air	Reduce heat losses • lag process equipment • insulate buildings	Purchase new vehicles
Educate work force	Consider fuel switching	Install new lighting
Investigate fuel purchasing arrangements	Increase frequency of maintenance work	Re-motor equipment

Figure 8 **The right truck for the right load can save fuel**



Implementation

Putting the plan into action

An energy plan – which must have the support of the owner or senior management – must contain realistic targets if it is to be a success. These targets should be:

- measurable,
- achievable,
- time-based,
- capable of being monitored,
- based on acceptable standards.

In pursuing these targets, a clearly defined routine is vital. Regular meetings must be held to discuss progress and, where necessary, to re-adjust targets to take care of unforeseen circumstances.

Ultimately, energy conservation should become an integral part of the operation of every company and second nature to both managers and employees. To achieve this, the energy co-ordinator must find ways of motivating the work-force. One way is to ensure that the savings made are displayed – perhaps using simple graphical presentations – so that staff throughout the company can identify with the success being achieved. Another is to find out how employees are motivated and harness the organisation's structure to the cause of energy savings. For example, many companies have bonus schemes related to return on capital which could be used to reward those who contribute to energy savings.

Every attempt should be made to educate employees and managers about the importance of energy efficiency in general and the company energy plan in particular. The energy co-ordinator also needs to identify those lines of communication that can be profitably used for broadcasting energy information. For example, he or she should participate in working groups of employees convened to discuss improving the way jobs are done and hence boosting productivity. Here, he or she can feed in his energy problems and ask for advice.

Once the plan is implemented, all concerned must be kept up to date with progress. The information provided for employees must clearly reflect the benefits resulting from their efforts. Large posters can be effective in ensuring the continuing cooperation of staff, and outstanding contributions to energy conservation can be highlighted on noticeboards, in the company newsletter or in a special newsletter created to provide energy information.

Reaching for the future

Once energy conservation has been integrated into the operations of a company, it will be a continuing challenge to all. The increased awareness and involvement of employees in the running of the company often leads to significant improvements in productivity and quality control. Attempts to save energy usually lead to challenges about the way the work is carried out, and thence to new techniques and approaches which improve the overall efficiency of the company.

An energy plan can also play an important role in the process of industrial growth and expansion. In the developing countries in particular, finance is increasingly being made available for industrial expansion by organisations ranging from the World Bank to national governments and local financiers. Environmental impact statements are often required from those applying for these loans, and the existence of an energy plan can play an important role in convincing authorities of the seriousness of a company's attitude to environmental issues.

Finally, as we have seen so often recently, the world of energy supply is far from stable. It is important to bear this in mind when choosing energy sources. The most economical choice today may not be the preferred choice tomorrow. Fuel cost is not the only consideration here: reliability of supply is also important.

The improvement of energy efficiency can provide substantial benefits to most industrial companies – and, indeed, to individual consumers. Far from being yet another expense that is hard to justify in the name of the environment alone, it provides – as hard experience has proved to many organisations – an effective way of achieving three simultaneous objectives: reducing costs; improving productivity; and, by no means least, minimising the impact of industrial activity on the environment.

Case history

Many bus depots are cavernous buildings, with large doors to allow easy entry and exit for the buses. Heating is invariably inefficient and therefore costly.

A UK bus operator decided to improve his heating, a ducted warm air system, which heated areas unnecessarily and resulted in large heat losses through draughts.

Radiant heaters were installed for an investment of £90 000. More efficient boilers were purchased and a series of radiant heaters positioned above those areas where the heat was required. (Radiant heaters are particularly effective in buildings where draughts are difficult to control.) The large upper spaces of the bus depot were no longer being heated unnecessarily, and the rate of heating could be controlled effectively.

In addition, direct-fired hot water generation was installed for use in the canteen and toilets. Energy consumption was further reduced by improving the opening and closing procedures of the doors and by fitting draught excluders to them.

Related publications

Managing energy efficiently is an introduction to energy auditing which demonstrates how industrial management, especially in small and medium-sized operations, can start to explore the potential benefits of improved energy efficiency.

Related publications which might be of interest include:

- SBS number three, 1991: *Energy in profile.*
- Briefing note: *Energy efficiency.*

Selected Papers:

- *The environmental challenge and the oil industry's response* by Freek Rijkels.
- *Global warming: the role of energy efficient technologies* by Ged Davis.

Speech:

- *Business and the environment: an industry view* by J.M.H. van Engelshoven.

Information on ordering these and other publications can be found on the inside front cover of this briefing.