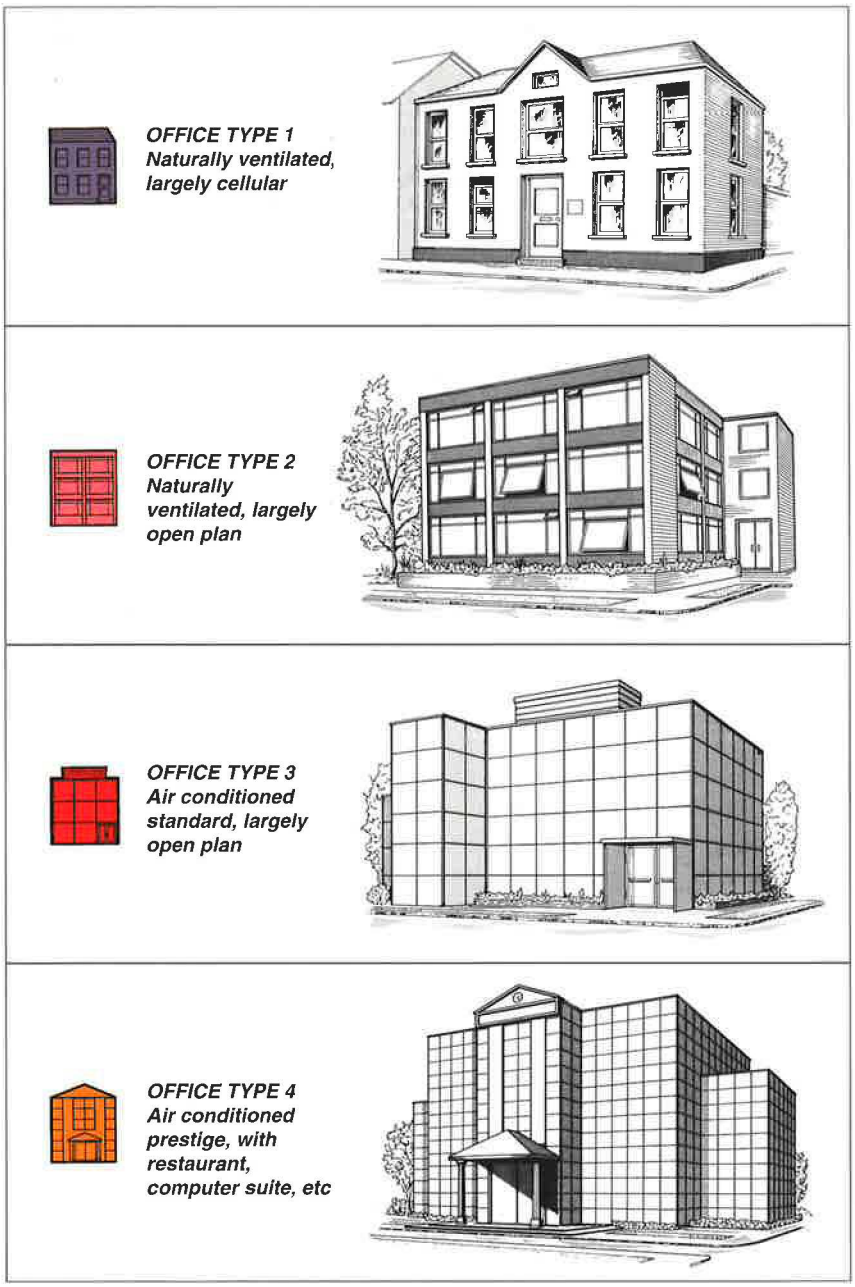
Guide 19

Energy efficiency in commercial and public sector offices



- Energy consumption and cost yardsticks
- Comparison shows energy cost saving potential
- Data broken down into a range of end uses
- First steps for improving energy efficiency

This Guide is intended to encourage people responsible for the energy bills of office buildings to make energy cost savings.

It allows comparisons to be made between the energy consumption and cost of the reader's building and yardsticks for typical and good practice offices. This enables targets for realistic energy savings to be set. Energy efficiency opportunities which will help those targets to be achieved are offered.

Annual delivered energy consumption can range from under 100 to over 1000 kWh/m^2 of treated floor area, costing from £4/m^2 to £40/m^2 or more at 1990/91 prices. Average and good practice patterns of energy use and cost are outlined for the four typical office types sketched to the left. The information in this Guide is based upon data collected from some 400 typical and best practice office buildings.

Energy costs in good practice offices are usually 30-50% below average levels, as Case Studies and other publications in the DOE Energy Efficiency Best Practice programme demonstrate (fig 1). Many savings measures are proven and cost effective when undertaken as part of ongoing new construction, refurbishment and alteration work. Some of them, particularly improvements to lighting, controls and management, are also often viable in their own right.

BEST PRACTICE PROGRAMME

ENERGY EFFICIENCY
DEPARTMENT OF THE ENVIRONMENT

OFFICE TYPES

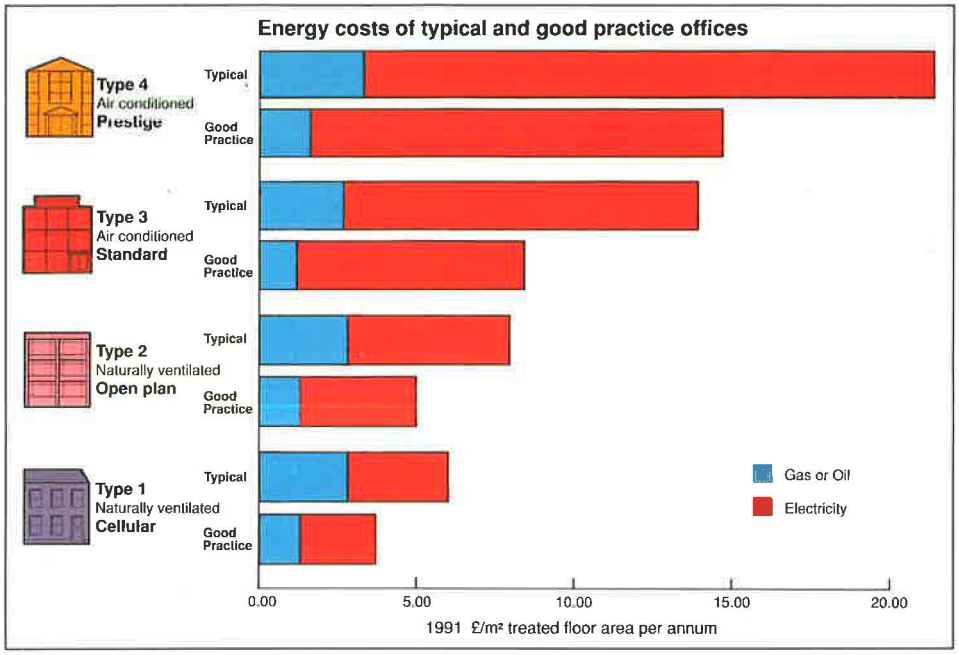


Fig. 1 Average and good practice energy costs for the four different offices

The four different office types

The patterns of energy use and cost in the four types of office give some reference points against which you can judge your own buildings.

Individual offices may contain features of more than one of the four typical examples; in this case, comparisons can be made against a combination of figures from the different office types.

Annual electricity and fossil fuel use and costs are shown for:

- a "typical" example near the middle of the consumption range for the national office stock as a whole, and
- a "good current practice" building, well managed and using simple, readily available and proven technologies and design features.

The values given for "good current practice" are drawn from energy consumption data in Case Studies of energy efficient offices. The buildings and refurbishments featured in the Case Studies, published under the EEO Best Practice programme, are already several years old and would perform even better with today's plant, lights and controls. The examples do not deal explicitly with all-electric offices which, like for like, usually have rather lower annual energy consumptions but higher energy costs.

Savings are not only possible within a given building type: in favourable circumstances one may also be able to achieve a less energy-dependent design. The Case Studies of Refuge House, NFU Mutual and Avon Group, and Hereford and Worcester County Hall (EEO Good Practice Case Study numbers 20, 13 and 17 respectively) demonstrate this by reducing the need for electric lighting and air conditioning in what could have been a fully air conditioned design, whilst still offering prestige offices. Instead, use of air conditioning and electric lighting is minimised through a 'mixed mode' approach, which uses natural ventilation and daylight when and where possible, with much of the building using full air conditioning only for limited periods of the year.

THE DIFFERENT OFFICES

OFFICE TYPE 1
Naturally ventilated cellular

A fairly small, simple building with largely individual offices, and perhaps a few group spaces. Daylight is good while artificial lighting is usually less intense than in the other three office types, and easily controlled by individual switches by the doors. There are few common facilities and catering is usually restricted to the odd sink and kettle.

OFFICE TYPE 2
Naturally ventilated open plan

Largely open planned but with some cellular offices and special areas such as conference rooms. Light levels and lighting power tend to be higher, and with deeper plans daylight is less available. Lights also tend to be switched in large groups. There is often more office equipment, vending machines etc..

OFFICE TYPE 3
Air conditioned

Similar in occupancy and planning to Type 2, but usually larger and with a deeper floor plan and tinted or shaded windows which reduce the availability and use of daylight still further. The air conditioning system may be either all-air (for example variable air volume) or air/water (for example induction units or fan-coils).

OFFICE TYPE 4
Prestige air conditioned

Larger still, and often a national or regional head office, with a computer suite, a restaurant serving hot lunches for at least half the staff, and a generally higher level of equipment, facilities and information technology. Hours of use are also extended owing to the more diverse pattern of occupation.

Note on hours of use

Energy use is sometimes also standardised for hours of occupancy or plant operation, but linear corrections tend to introduce more discrepancies than they resolve. Most offices are intensively occupied for about ten hours a day, five days per week, with another hour or two at the beginning or end of the day for cleaning. At other times, only a few people remain (except perhaps in special areas such as data processing) and only local heating and lighting should be required. If everything stays on, that is a problem to be exposed, not concealed by increasing the energy target. It is often more instructive to state the reasons why the intensity of use is high (eg: regular Saturday or multi-shift operation) or low (eg: if the building is partly empty), than to make arithmetical corrections.

NFU Mutual and Avon Group Head Office designed to avoid air conditioning in most areas

Notes on floor area

To compare buildings, it is convenient to standardise annual consumptions in terms of energy use per unit floor area. Here we use treated area (see below). A paper on floor area measurements and definitions is available from BRECSU upon request.

As simple working rules and excluding car parks, attics, and large stores, ratios of treated to gross and nett lettable area for reasonably space efficient offices will be in the region of:

	Treated to gross	Nett to treated	Nett to gross
Type 1	95%	80%	76%
Type 2	95%	80%	76%
Type 3	90%	80%	72%
Type 4	85%	80%	68%

These figures should be used for initial checks only: for more detailed comparisons measurement of your own buildings is recommended: individual offices can easily deviate by ±5% from these norms, and areas obtained from files or colleagues are often inaccurate.

Short Notes on the Measurement of Floor Area

Gross	Total building area measured inside external walls
Nett	Gross area less common areas and ancillary spaces. Agent's lettable floor area.
Treated	Gross area less plant rooms and other areas (eg stores, covered car parking and roof spaces) not directly heated.

Typical annual energy use

Annual energy use in a typical office for each of the four office types (Fig. 2).

- Fossil fuel consumption (in the diagrams for heating, hot water and catering only) is similar for all four: air conditioned buildings often requiring slightly more, owing to higher fresh air loads over a longer heating season and simultaneous heating and cooling from time to time. The prestige air conditioned (type 4) office also has longer operating hours and extra requirements for the kitchen and the associated hot water supplies.
- Electricity consumption rises rapidly with increasing complexity from the simple to highly serviced office types. Heating system pumps, burners and controls in the simple naturally ventilated type 1 office use relatively little; they are likely to use rather more in the open plan type 2 office as mechanical ventilation for toilets, meeting rooms etc. is more likely. In the air conditioned type 3 and 4 offices, fans, pumps and controls use considerably more electricity, particularly the fans in all-air systems, where refrigeration energy is often lower owing to "free cooling" cycles using outside air. In air/water systems — for example fan-coils, fan energy is lower and refrigeration energy higher, though not usually by quite as much.
- Lighting energy consumption rises progressively across the range of offices as the use of daylight tends to fall, illuminance standards and hours of use rise, and internal rooms become more common. In open plan offices, light switching also becomes a more complex issue, and lights usually stay on much longer than really necessary unless well designed automatic and manual controls are fitted.
- Electrical consumption by office equipment tends to increase across the range as operations become more sophisticated and intensive. Equipment loads are rising at present with growth in information technology, which also increases the perceived need for air conditioning. However, heat output is often less than expected and by the end of the decade it could fall as equipment becomes less demanding of power, particularly once levels of equipment reach saturation.
- Electrical use by lifts, telecommunications systems and ancillaries such as car parks and external lighting is classed as "other". These all tend to grow with the complexity and sophistication of the building as a whole, as does the energy use for catering.
- The computer room figure varies widely. Here an average is given from a number of surveys of offices with mainframe computer suites occupying perhaps 5% of nett floor area. Dedicated computer centres use much more energy and are not covered here. Typical electricity consumption by computer air conditioning is 60-80% of that of the computer equipment etc.

Good Practice energy use

The companion figures (Fig. 3) for good current practice (which are based on the assumption that the electricity used by office equipment and mainframe computers is the same as for the typical office figures) show that heating costs overall can be more than halved and electrical costs cut by at least one-third by using readily available methods.

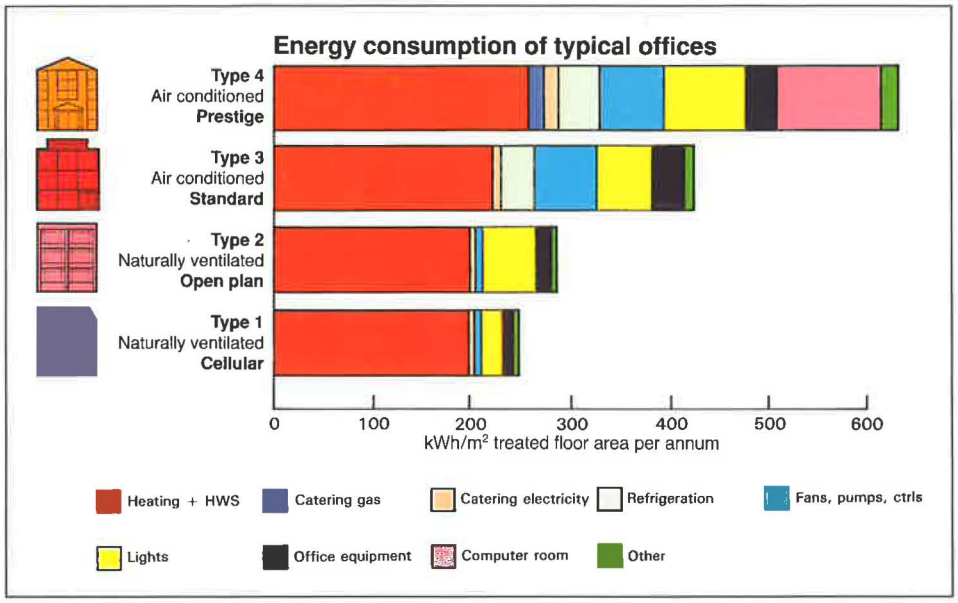


Fig. 2 Energy consumption of typical offices

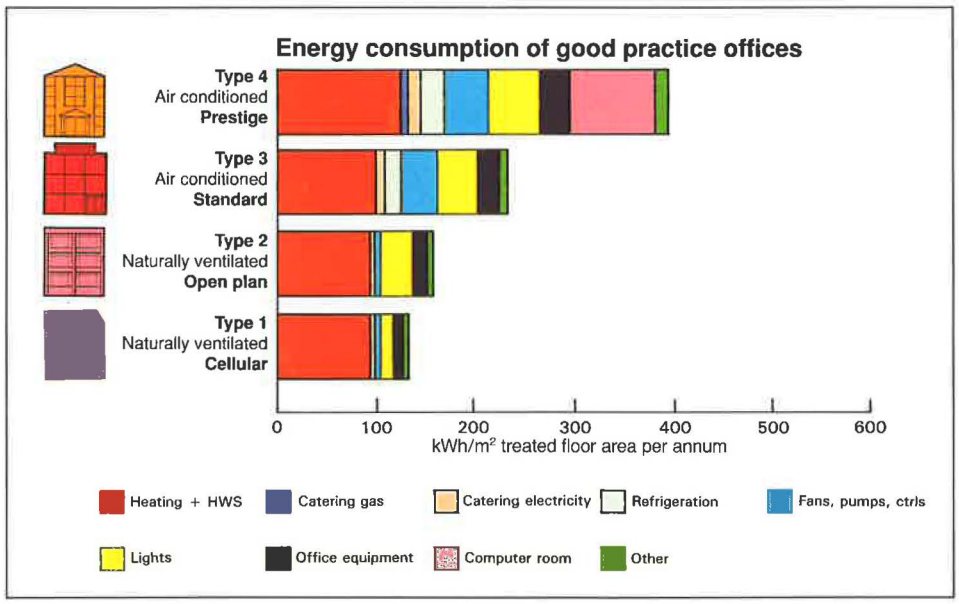


Fig. 3 Energy consumption of good practice offices

These good practice levels are by no means the ultimate achievable, particularly in new buildings and major refurbishments. For example, most of the Case Studies indicate scope for further improvement, and few include condensing boilers and high frequency lighting, which can now be specified with confidence.

How are the reductions achieved?

- The lower fossil fuel consumption is attributable to better insulation, more efficient boilers, improved control and management, and more efficient hot water systems. In existing buildings, substantial savings are often possible by attention to plant and management without necessarily improving insulation, as the Case Studies of Heslington Hall (16) and Quadrant House (18) show.
- Lower electrical costs for HVAC systems arise not only from better control and management, but also from designing systems with low pressure drops and consequently low fan power, as in the One Bridewell Street Case Study (21).
- Lighting has improved massively over recent years, and it is now often possible to light offices well at 2.5 Watts per square metre per 100 lux or less with modern fluorescent tubes, efficient reflectors, and electronic high-frequency ballasts. In the 1970s one would have needed two or three times the power for a similar result.

Electronic controls — as fitted in several of the case study buildings — permit lights in open offices to be managed more economically. They can also give more individual control,

This office with high frequency lighting has an installed load of 8.5 W/m² (as against typically 15-20 W/m²) and includes automatic dimming for further savings.

Annual Delivered Energy Consumption of Typical and Good Practice Offices for the four office types (kWh/m² treated area)

	Type 1		Type 2		Type 3		Type 4	
End Use	Typical	Good Practice	Typical	Good Practice	Typical	Good Practice	Typical	Good Practice
Heating + Hot Water — gas or oil	200	95	200	95	222	100	259	124
Catering gas	0	0	0	0	0	0	14	8
Catering electricity	3	3	5	4	7	7	14	12
Refrigeration	0	0	0	0	33	17	41	24
Fans, pumps, controls	3	3	6	5	61	39	71	47
Lights	26	16	53	32	67	39	82	47
Office equipment (variable)	11	11	16	16	22	22	29	29
Computer room (variable)	0	0	0	0	0	0	106	88
Other	5	4	5	4	11	9	18	14
Total gas or oil	200	95	200	95	222	100	273	132
Total electricity	48	36	85	61	202	132	361	261
Total delivered energy consumption	248	131	285	156	424	232	634	393

Annual Energy Costs (1990-91 £/m² treated area)

	Type 1		Type 2		Type 3		Type 4	
End Use	Typical	Good Practice	Typical	Good Practice	Typical	Good Practice	Typical	Good Practice
Heating + Hot Water — gas or oil	£2.80	£1.33	£2.80	£1.33	£2.67	£1.20	£3.11	£1.48
Catering gas	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.17	£0.10
Catering electricity	£0.21	£0.17	£0.32	£0.25	£0.43	£0.37	£0.71	£0.59
Refrigeration	£0.00	£0.00	£0.00	£0.00	£1.83	£0.92	£2.06	£1.18
Fans, pumps, controls	£0.21	£0.17	£0.38	£0.32	£3.36	£2.14	£3.53	£2.35
Lights	£1.71	£1.03	£3.16	£1.89	£3.67	£2.14	£4.12	£2.35
Office equipment (variable)	£0.68	£0.68	£0.95	£0.95	£1.22	£1.22	£1.47	£1.47
Computer room (variable)	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£5.29	£4.41
Other	£0.34	£0.27	£0.32	£0.25	£0.61	£0.49	£0.88	£0.71
Total gas or oil	£2.80	£1.33	£2.80	£1.33	£2.67	£1.20	£3.28	£1.58
Total electricity	£3.15	£2.33	£5.12	£3.66	£11.12	£7.27	£18.06	£13.06
Total energy cost	£5.95	£3.66	£7.92	£4.99	£13.79	£8.47	£21.34	£14.64

The Department of the Environment's Energy Efficiency Best Practice programme provides impartial, authoritative information on energy efficiency techniques and technologies in industry and buildings. This information is disseminated through publications, videos and software, together with seminars, workshops and other events. Publications within the Best Practice programme are shown opposite.

For further information on:

Buildings-related projects contact:
Enquiries Bureau
BRECSU
Building Research Establishment
Garston, Watford, WD2 7JR
Tel 01923 664258
Fax 01923 664787
E-mail brecsuenq@bre.co.uk

Industrial projects contact:
Energy Efficiency Enquiries Bureau
ETSU
Harwell, Oxfordshire,
OX11 0RA
Tel 01235 436747
Fax 01235 433066

Energy Consumption Guides: compare energy use in specific processes, operations, plant and building types.

Good Practice: promotes proven energy efficient techniques through Guides and Case Studies.

New Practice: monitors first commercial applications of new energy efficiency measures.

Future Practice: reports on joint R&D ventures into new energy efficiency measures.

General Information: describes concepts and approaches yet to be fully established as good practice.

Fuel Efficiency Booklets: give detailed information on specific technologies and techniques.

Energy Efficiency in Buildings: helps new energy managers understand the use and costs of heating, lighting etc.

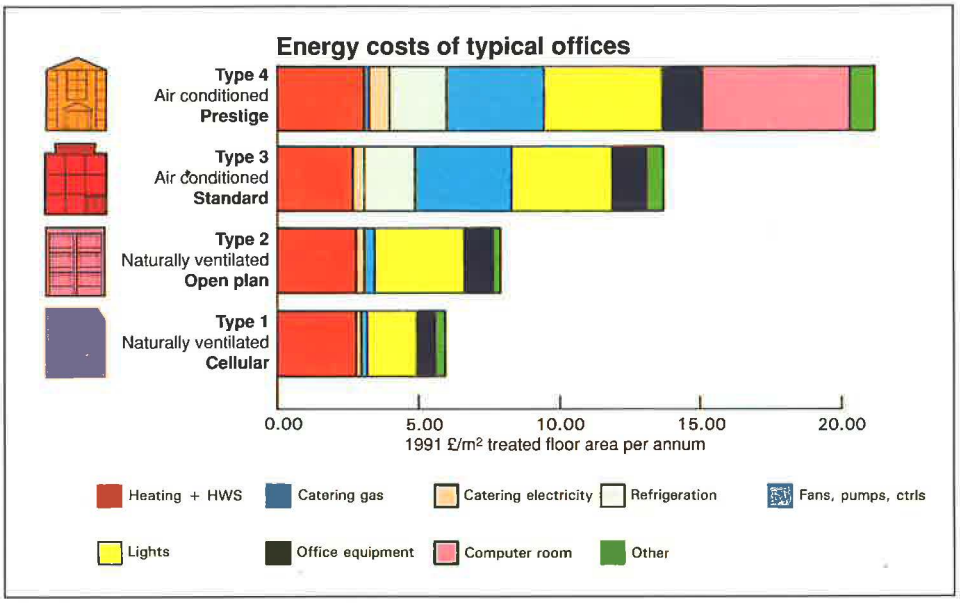


Fig. 4 Energy costs of typical offices

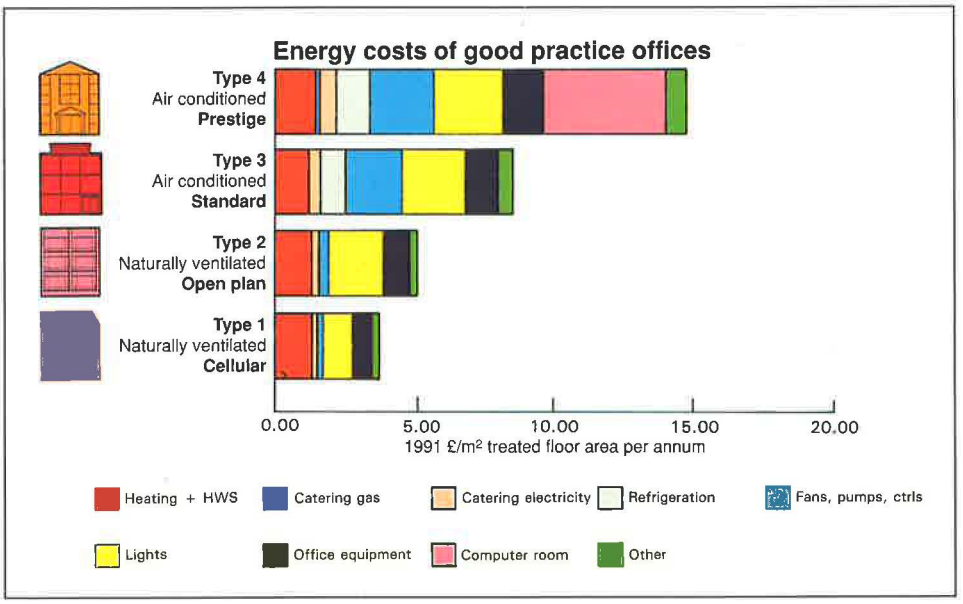


Fig. 5 Energy costs of good practice offices

through hand-held remote switches for example. However, controls have to be well designed and in cellular offices switches by the door often do a good enough job.

In corridors, WCs etc., and for many decorative purposes, compact fluorescent sources have made tungsten lighting superfluous, giving energy and maintenance cost savings for lamps which often burn for long hours.

At Hereford & Worcester County Hall new lamps and reflectors now allow one fluorescent tube to do the work of two old ones, using less than half the electricity.

- Small savings have been assumed for computer rooms, with lower lighting loads and a tendency now to run computers in darkness with operators elsewhere. Unified control of packaged computer air conditioning is also assumed, avoiding standby units running unnecessarily and adjacent units running autonomously under their own controls and cycling unnecessarily. Further savings can be made by using heat recovery or "free cooling" systems, as in the NFU Mutual and Refuge Assurance Case Studies, but they are not included here as it will not always be cost effective to go to such lengths.

- 33% savings have been assumed in catering, where equipment is often operated very wastefully. An important reason for this is that energy supplies to catering contractors are usually provided "free" by the customer. Sub-metering and re-charging is recommended to provide incentives.

- No savings are assumed for office equipment etc, though with careful selection and use some could be achieved.

Annual energy costs

The figures 4 and 5 show energy use data converted into money for the typical examples and good practice cases. Only in the simple type 1 office are fossil fuel and electrical costs similar: in the others electricity predominates owing to its much higher unit price. Note that the costs of both lighting and electricity for HVAC systems often individually exceed the cost of heating.

Typical fuel costs

Fuel costs vary with office size, type, region, contract and load profile. Unit prices tend to be lower for larger and more intensively serviced buildings. These are also more likely to be supplied at a higher voltage and have better load factors. The energy manager therefore has more bargaining power in negotiating with the energy suppliers.

Correctly apportioned electrical unit prices also vary with end use. For example, lower than average rates will apply for computer rooms and communications equipment (with better load factors) and for comfort cooling chillers (predominantly a summertime load). Conversely, higher rates will apply for kitchens (with poor load factors and usually contributing to maximum demand peaks at lunchtime), and humidifiers.

A full discussion of tariffs is beyond the scope of this Guide and the cost histograms here recognise the variations in a simple way by assuming the following average unit prices. In practice, electricity bills will usually be based on a maximum demand tariff.

Typical unit prices (p/kWh delivered)

OFFICE	Fossil	Electricity
Type 1	1.4	6.5
Type 2	1.4	6.0
Type 3	1.2	5.5
Type 4	1.2	5.0

Short notes on delivered energy units

Energy units are in kilowatt hours (kWh), the unit in which electricity is billed.

For other fuels, conversion factors are as follows:

NATURAL GAS
29.31 kWh/therm gross calorific value

Note

1 therm	= 100,000 Btu (British thermal units)
1 kWh	= 3.6 MJ

OIL

Gas-oil	10.6 kWh/litre
Light fuel oil	11.2 kWh/litre
Heavy fuel oil	11.4 kWh/litre

What can I do?

Understanding how energy is used in your building is the first major step to achieving energy savings.

- Collect your energy use and cost data for the past year or more.
- Obtain or measure the floor area of your buildings. If only gross or nett areas are available, use the conversion factors on page 2 for initial estimates.
- Consider how the overall annual electricity and fossil fuel use relates to the examples given, and if the monthly energy consumption pattern relates sensibly to the weather and to the pattern of use.
- Try to understand features of your buildings which might cause the consumption levels to be particularly high or low. If your electricity is on a DAY/NIGHT tariff the information can be invaluable in helping to estimate night-time loads such as in computer suites.
- Concentrate at first on the buildings or features which are particularly high energy consumers or offer the greatest potential for energy saving.
- If necessary, install and read meters to check the amount and pattern of energy consumption by major individual items, such as computer rooms, computer air conditioning, kitchens, chillers and large fans.
- Regularly review the information provided by meters.
- Prioritise the measures. Simple, highly cost effective measures can sometimes create cash reserves from utility budgets to help finance subsequent projects.
- Make use of opportunities. The best time to implement energy saving measures is on the back of an essential project, for example maintenance, alteration, re-equipment and refurbishment. Don't miss the chance.
- Keep it simple. Don't use any more, or more complex, technology than necessary to solve the problem effectively. Don't create unnecessary maintenance or management burdens.
- Refer to other Good Practice Guides as necessary.
- Carry out a full energy audit and survey. Refer to the CIBSE Applications Manual on Energy Audits and Surveys for guidance. The Manual is described further in Good Practice Guides 27 and 28.
- Seek professional advice if you require it.

Summary

Energy efficiency in offices is not only — or even mainly — about heating: electricity costs usually predominate, and offer good scope for cost effective energy savings.

Heating

For heating itself, better insulation is not the whole story. Many buildings, including well insulated ones, cost more to heat than they should owing to inefficiencies in plant, control and management. The situation is often worsened by oversized boiler plant, particularly when it runs poorly controlled in summer to make small amounts of hot tap water.

Air Conditioning

In air conditioned offices, people often regard chiller efficiency as paramount. However, with all-air systems the fans usually cost more to run, and attention to fan power and control can be more rewarding. Excess running hours often lead to unseen — and often undetected — waste. Hours-run meters on important items of plant can be helpful and parts of the office which are regularly used outside normal hours should be separately zoned and controlled.

Lighting

Lighting is often the largest individual item of energy cost, varying over a wide range depending upon installed power and hours of operation. In cellular offices people can easily use available daylight — as they do at home — and should be encouraged to do so. In open plan offices the situation is more complex and the lights often tend to stay on all day, whether or not they are required. New lamps, reflectors and controls can often give major savings, particularly for the lights which burn for the longest hours.

Computer Suites

Mainframe computer suites can sometimes account for more than half the entire energy bill. Their air conditioning often runs inefficiently and offers scope for substantial savings through improved control and management. If possible, power supplies to the computer and its air conditioning should be separately metered and regularly monitored: if the ratio of air conditioning to computer consumption is more than 0.6, there may well be scope for improvement. Unified control should be considered for installations made up from independent packaged units.

Office Equipment

Although office equipment often uses less energy than people expect, averaging perhaps one-third of the labels on the back, leaving it on unnecessarily — and particularly overnight — should be discouraged. Purchasing decisions should take account of energy requirements: some brands and types of equipment are considerably more energy efficient than others, and their lower heat output also helps to reduce both the need for air conditioning and the cooling loads it has to serve.

Good Management

Good management is essential. Energy efficiency is not an end in itself, but a reward for meeting the organisational and user needs in an effective and professional manner. Important aspects include:

- Matching performance standards and operating hours to user needs.
- Regular checking of control functions.
- Regular reviews of fuel bills and sub-meter readings.
- Good maintenance of plant.
- Attempting to site office equipment with high heat outputs in places where it does not unnecessarily increase cooling loads or the need for air conditioning, for example in areas with separate local air extract systems.

Building Energy Management Systems

When considering advanced electronic controls and Building Energy Management Systems (BEMS), don't take them for granted: the systems are an aid to good management, not a substitute for it.

Tariffs

Finally, you may be paying more for your fuel, and particularly your electricity, than you should. More economical tariffs may be available (for example DAY/NIGHT if you have a large night-time computer room load). You may also be able to take steps to improve power factors or maximum demand profiles.

This is the first time that yardsticks for detailed energy uses in offices have been presented in the present form. It is possible that ongoing studies of further Good Practice Case Studies, combined with trends in office building, will lead to future revisions of the yardsticks for both typical and "good practice" offices.