Low Carbon Fit Out.

Low Carbon Fit Out. *Forward.*

Low Carbon Fit Out Guide has been produced to provide practical and technical guidance to retailers.

It has been drafted in collaboration with *Hoare Lea*, *Foreman Roberts* and *WSP* whom provide worked examples and technical analysis to illustrate the benefits, costs and efficiencies of those installations.

Contents

Low Carbon Fit Out.

1.0 *Introduction*

Land Securities are responsible for the *development and operation* of a significant number of retail properties *throughout the United Kingdom* and is putting *sustainability* at the *heart of the development process.*

In 2009, we developed the 'Retail needn't cost the Earth' sustainability document highlighting the importance of sustainable development and the difference Land Securities and our retailers can make by working to a common goal. This document should be seen as a supplement to the sustainability brochure and provides detailed guidance on the practical ways our retailers can reduce energy by good practice design and effective energy management.

This document has been developed in collaboration with three of the UK's leading engineering design consultancies who are able to draw upon the wealth of experience they have in the retail sector. Worked examples are provided illustrating the opportunities available to our retailers by reviewing current approach to fit out and adopting 'Best Practice' design.

The contact point is:

Retail
Eamonn Driscoll
Engineering Manager

Land Securities PLC
5 Strand LONDON WC2N 5AF
D/L: +44 (0) 207 024 5122
D/F: +44 (0) 207 024 3880
eamonn.driscoll@landsecurities.com
www.landsecurities.com

London Portfolio
Steve Davidson
Project Engineer

Land Securities PLC
5 Strand LONDON WC2N 5AF
D/L: +44 (0) 207 024 3826
D/F: +44 (0) 207 024 3770
steven.davidson@landsecurities.com
www.landsecurities.com

2.0 *Why Change?*

2.1 The Environment

Scientists recognised that harmful greenhouse gases need to be reduced to minimise the effect of global warming. Leading nations are collectively trying to combat this threat and protect the environment for future generations.

Businesses which rely on energy to operate are responsible for carbon emissions. Land Securities believe there are significant opportunities in their retail developments to work with tenants to reduce environmental impact with benefits to the retailers and customers as detailed in this guide.

2.2 Legislation

The EU has entered into a carbon reduction agreement to reduce carbon emissions by 80% from 1990 levels by 2050. Legislation is becoming increasingly more onerous to reduce energy and carbon emissions associated with new and existing developments. The most notable changes for Land Securities and retailers are the increasing requirements of Building Regulations (part L) which set out the basis for the minimum energy efficiency and performance of plant and equipment to be used. Retailers should also be aware of the requirements under the Carbon Reduction Commitment as well as Energy Performance and Display Energy Certificates – see appendix 4

2.3 Customer expectation

The general public are increasingly aware of the effect of global warming through the media and this is influencing customer choice and this is recognised by some of the larger retailers operating in the UK. Land Securities believe there is an opportunity for retailers to offer customers a sustainable retail environment as greater public awareness regarding energy and carbon emission grows.

2.4 Improved retail environment

A closely controlled environment and good lighting design can significantly improve the retail environment in addition to the benefits that can be achieved from an energy reduction point of view. Examples of this can be found in this document. An improved retail environment can boost dwell time and sales.

2.5 Energy Costs

Energy costs are increasing and indeed may continue to do so. Reducing energy demand, and associated operating costs will increase profits.

2.6 Installation Costs

Land Securities are mindful that one of the key considerations for many of our retailers is the cost of initial fit out and hence, examples are given of how best practice compares with standard part L compliant installations. This is aimed at assisting customers through the evaluation process to determine the underlying cost of working on a best practice basis.

"Land Securities believe there are significant opportunities in their retail developments to work with customers to reduce environmental impact..."

3.0 *Energy Use in Retail*

3.1 The retail sector contributes around 7% of the total energy consumption within buildings in the UK, and causes 5 million tonnes of carbon dioxide per year to be emitted. The distribution of energy consumption will naturally vary depending upon the type and scale of the retail outlet. A typical proportion of energy uses, displayed in the image below, shows the areas where the largest potential energy savings could be made. These areas are heating, lighting, cooling, refrigeration and catering and ventilation.

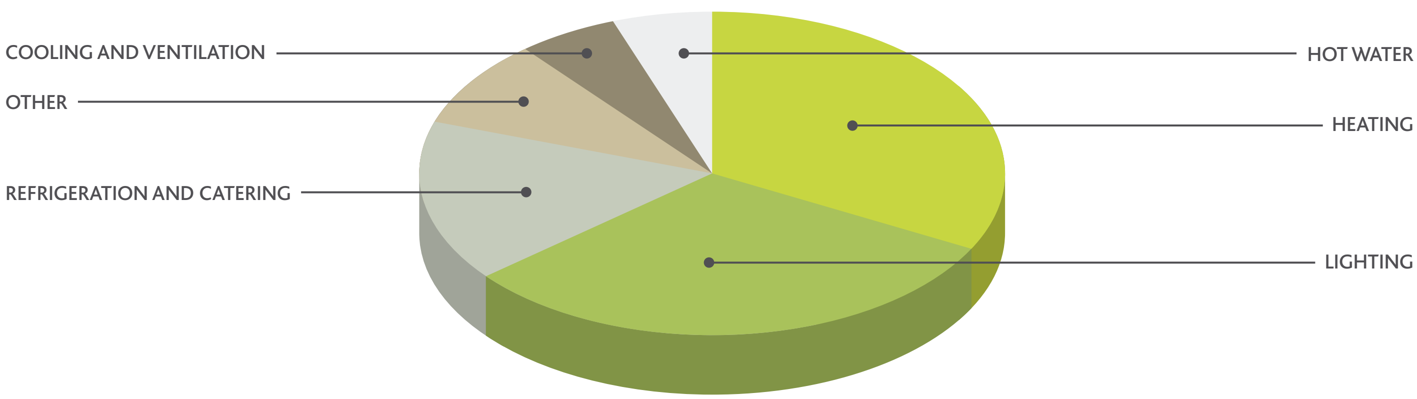


Fig.1 Typical proportion of energy usage for a retail unit. **Source: The Carbon Trust**

4.0 *Low Carbon Opportunities*

4.1 Energy efficient equipment

Choosing energy efficient equipment and appliances can have a considerable effect on resultant energy bills. Not only does the equipment have a direct contribution, but often the waste heat emitted by inefficient equipment is subsequently lost into the air conditioning system.

In most cases, however, there are statutory minimum energy efficiency standards for building services systems and items of equipment; these are detailed within subsequent sections of this toolkit.

However, regarding other items such as White Goods, an energy rating of A or above should be favoured. Additionally, items which have been listed within the Government's Energy Technology List should be considered (which can be found at the following website: www.eca.gov.uk/etl) – current at time of publication.

It should be noted that small or medium-sized enterprises that have been trading for at least 12 months may be eligible for an Energy Efficiency Loan. These loans are interest free and sums between £3,000 to £100,000 are available (repayable over 4years) for items such as:

4.1.1 Condensing boilers, which can achieve Seasonal Efficiencies in excess of 90% compared to more conventional forms of boilers. Condensing boilers are most effective with low return temperatures.

4.1.2 Heat exchangers, which can be used to recover and reuse waste heat.

4.1.3 Lighting, which is one of the largest consumers of energy within retail buildings, the influence of low energy light fittings is covered in detail in this toolkit; and

4.1.4 Insulation, which will limit heat loss from hot water and cooling system pipework etc.

By choosing energy-efficient equipment and controlling the operation to avoid additional wasted energy, retailers can save a substantial amount on their electricity bill.

4.2 Reducing loads

By carefully managing building loads, you can reduce the size and cost of the Heating Ventilation Air Conditioning (HVAC) equipment. In addition, a more appropriately sized HVAC system will provide improved thermal comfort and may achieve better ventilation.

Store owners, managers and facilities staff need to appreciate the entire process - increased attention to design at the outset of a project can result in systems that cost less to install and less to operate, and a regular maintenance routine can facilitate high performance throughout the life of the equipment. To maximise the benefits, the following should be noted.

- Operate equipment effectively and arrange your store so that heat sources and furniture do not obstruct light switches, thermostats, supply air vents and intake grilles will reduce the cooling and heating load on your system, providing more economical operation.
- Select the most appropriate space temperature according to the activities within the space and the season. Note that when cooling, your operating costs increase from 3% to 8% for each degree your thermostat is lowered.
- Energy loads can also be reduced by influencing attitudes to energy consumption. Closing doors and turning lights off when they are not needed are simple common sense approaches that can be promoted amongst staff.
- Zoning or Programmable Thermostats can control your equipment according to use and daily occupancy patterns. This will limit energy consumed for conditioning areas that are unused or unoccupied.

4.3 Heat recovery

Heat Recovery from mechanical ventilation effectively transfers the heat, which would otherwise be wasted, from air extracted from the shop, or kitchen space. The recovered heat can then be used to pre-heat or pre-cool incoming outdoor air needed for ventilation, so reducing the energy and cost for heating or cooling.

There are a number of product and system types available and their use generally depends upon the resultant application. The types include:

- Air-to-air heat exchangers
- Evaporative heat exchangers
- Thermal wheels
- Run-a-round coil systems

Heat exchangers are typically between 50% and 80% efficient, therefore, when integrated as part of your air conditioning and ventilation fit out, they will have a beneficial impact on your heating and cooling energy consumption.

It should be noted that introducing heat recovery will increase fan power and this should be considered when assessing the overall system energy preformance.

4.4 Low or zero carbon technologies

It is appreciated that opportunities for retail tenants to integrate and utilise renewable energy are limited, however, some landlords have committed to substantially reducing carbon emissions from their buildings and have set targets to reduce energy consumption and CO_2 emissions.

Evidence of this can be seen with the increasing adoption of site-wide and landlord services provisions such as Chilled and Condenser Water Loops, and the use of technologies like Combined Heat and Power.

Retailers should consider utilising the landlord low carbon services provision where appropriate or for larger stores i.e. anchor stores, consider installing their own as follows:

4.4.1 Condensing Water Loops reclaim heat that is conventionally rejected, so improving the efficiency of energy use. However to make the most of this system, a relatively constant heating demand is necessary, either to supplement process heating requirements or space heating. Typically this system will be provided as part of the Landlords provisions, however it is possible for larger Anchor stores to develop a localised system.

4.4.2 Solar Thermal systems use the sun to produce hot water and solar PV uses the sun to generate electricity. Solar thermal is one of the more affordable renewable technologies available and PV one of the most expensive. These systems are particularly suited to retail outlets with consistent demands for hot water or electricity during daylight hours. If there is access to a south facing roof or facade then the addition of solar thermal or PV may be possible.

4.4.3 Biomass energy production may also be an option in instances where the heating and hot water demand are consistently high and there is sufficient space to store the biomass. If the nearest source is too far away or if delivery is likely to be unpredictable then this would not be a suitable option.

In some instances retailers have developed systems which reuse packaging and wastes' derived from their own activities – reducing fuel costs and waste disposable costs. The need for storage facilities and the relatively large size of biomass boilers means this system favours larger premises. There are also local air quality issues to consider.

Low Energy Design Guides

Lighting

5.0 *Lighting Design Guide*

5.1 Introduction

The size and type of a retail unit often dictates the approach taken in lighting design.

To this end, the following design guide is provided to promote better awareness of the impacts poor lighting specification may have on a retail fit out in terms of energy use and performance.

It is also provided as an aid to retailers in assisting fit out design appraisals necessary to reduce energy consumption, often dictated by lease agreements.

5.1.2 Building Regulations. Part L : Conservation of Fuel and Power

Retailers must demonstrate compliance with Building Regulations as part of their fit out approvals. Part L of the Building Regulations relates to the conservation of fuel and power and retailers must provide documented evidence to the local planning authority in order to demonstrate that the installations comply with the emissions targets stipulated with Part L. A combination of factors are considered within the Part L assessment method such as building fabric losses, plant performance, heating fuel sources and lighting efficacy declared in terms of Watts per m^2. As a result, lighting design has a significant role to play contributing to the overall carbon emissions from a particular retail unit. For example, poorly selected fittings may impact upon associated cooling loads required to offset inclement heat gains from luminaires.

As part of the fit out design process, the fit out design team must consider Part L performance targets from the outset in order to ensure compliance can, and will, be achieved. The following guidance notes are provided to assist in that process.

5.2 Current Trends

5.2.1 Design

The design of lighting to retail units is tackled in many ways and can be led by a number of different disciplines, dependant upon the retailer organisation and their fit out philosophy.

As such, the specification and selection of the luminaires may be carried out by any of the following, as part of a retailers design and delivery team:

- Lighting Designers
- Electrical Engineers
- Retail Designers
- Interior Designers
- Shop Fitters
- Lighting Manufacturers
- Electrical Contractors

Each of these providers will bring a different bias to the design process, each being driven by a different emphasis. For some creativity and strong design will be paramount, for others cost is the ultimate driver. A varying degree of knowledge will also be exhibited, some will be at the forefront of the latest lighting technology, others will adopt tried and tested methods that, although functional, are no longer appropriate and not in keeping with current policies.

Brand managers or in-house designers will often dictate the style and positioning of large chains and could employ the use of external experts to realise their aspirations. Smaller one-off brands may not have the necessary budgets to allow this and would be more reliant upon smaller local fitters, who may not always be as up to date with the latest knowledge. Certainly, retail fit out has become far more sophisticated with greater opportunities for luminaire selections than ever before.

Often, time and planning are driving factors in the specification of the lighting. The lighting installation is, therefore, often left to the last minute of a short fit-out program. It is then easier to refer to previous schemes and copy this approach rather than consider new. This solution continues any poor design into new outlets. Availability and stocking of luminaires also proves to be significant with a need for suitable units to be available off the shelf.

5.2.2 Controls

Depending upon the size of the retail unit, the current method for lighting control can be very much all or nothing; all on or all off.

Carbon emissions can be reduced by up to 27% by the application of simply enhanced controls

Control can constitute simple manual switching, reliant upon employees to alter the lighting. This is very much at odds with the methods now used in control systems in commercial environments where the lighting is controlled automatically, reacting to movement, occupancy, illuminance levels, time of day, function etc. Certainly, where automatic controls are not appropriate or cost prohibitive, opportunities are not provided by the fit out for staff to control the lighting in an efficient manner.

There are generally 3 modes of retail lighting:

- Shop Fronts
- Trading
- Re-stocking

Shop front lighting is generally left on all day, regardless of the time of day, external environment etc. Often this lighting uses many high powered luminaires in an effort to try and compete with daylight or neighbouring retail outlets. Some fit out lighting should be turned off once a mall is closed to the public.

In certain stores, during periods of restocking, the illuminance levels are not reduced. By simply switching off every other luminaire or row of luminaires a reduced lighting level to the shop floor may be provided. The manually switched circuiting of the lighting could be readily designed to allow for such measures.

Back of house areas are manually switched and can be left on. Simple controls are starting to appear in some back of house areas where presence detectors (PIR) are beginning to be employed, however, this is not yet common practice.

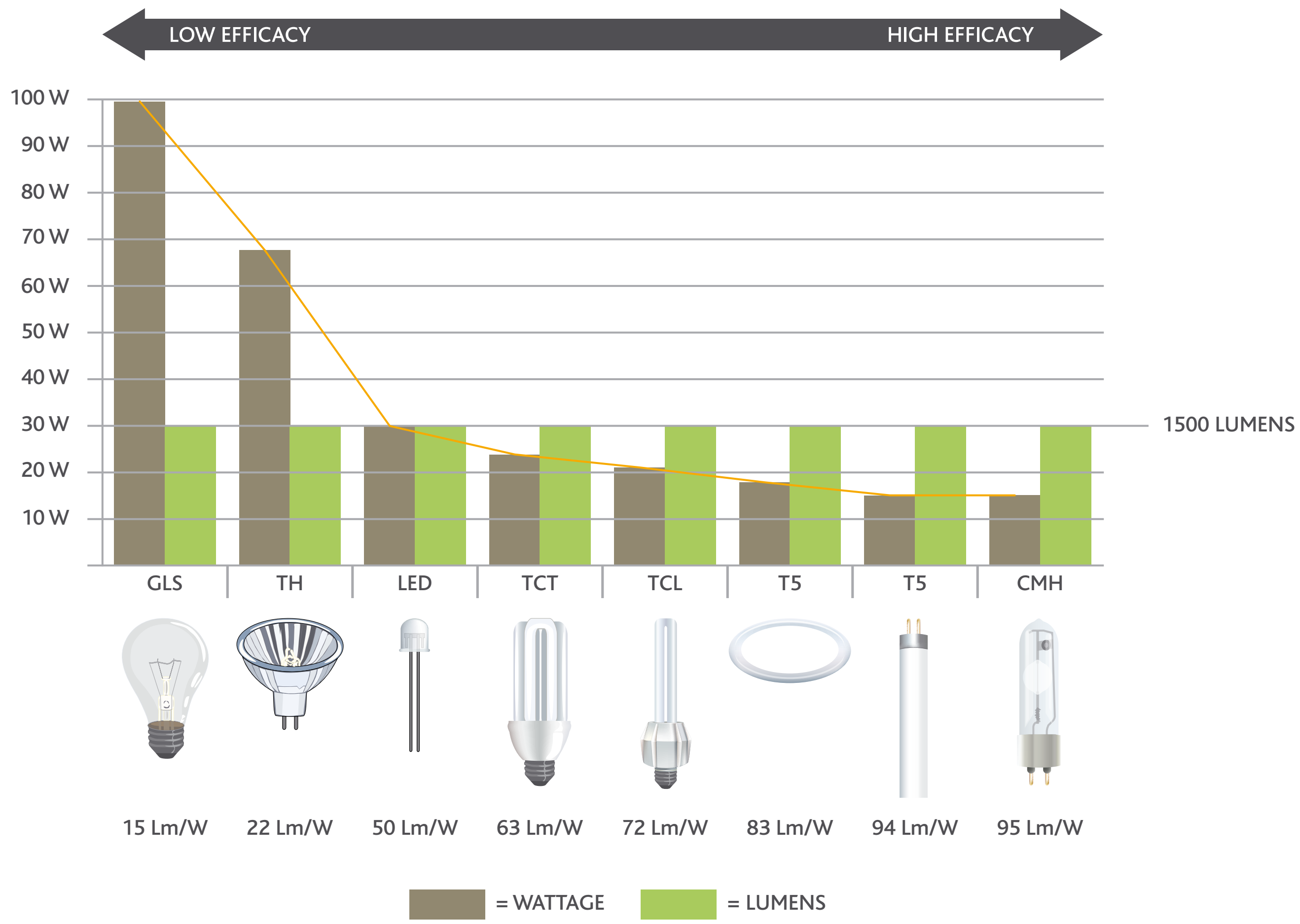
Depending upon the size of the unit, significant savings can be made in both energy costs and carbon reduction by the application of the most basic controls. In larger units a fully automated system would be expected.

5.2.3 Illuminance Levels
These vary greatly across different store types and different task planes. They will also be affected by the interior design concepts for each store.

The interior design of the outlet will significantly affect the lighting design. Some stores are treated as a white box and provide high lighting levels across all working planes, horizontal and vertical, with high uniformity, everything therefore looking equally bright. Other units introduce areas of light and dark within the field of vision, allowing the lighting to draw the eye to the brighter zones. Colour and texture is used to further enhance this look, introducing areas of contrast within the interior design scheme.

5.3 Lamp Selection (Lamp Efficacy)
The graph below illustrates the amount of energy (Watts) each lamp type consumes in order to achieve a figure of 1500 Lumens.

From this the efficacy (Lumens per Watt) of each lamp source can be obtained, the higher the efficacy the more light per watt is produced. (lumen = the amount of light emitted)



The orange line demonstrates how higher efficacy lamps use less energy to provide the same lumen output as lower efficacy lamps

Fig.2 Efficacy of lamp alternatives

5.0 *Lighting Design Guide*

5.4 Lamps

General Lighting Service (GLS)	Pros	Cons
Seldom used for general or focused lighting. Primarily used within feature elements	• Cheap and easy to source • Dimmable • Excellent colour rendering • Instantaneous light	• Short life span, 1000 hours • High running costs • Soon to be obsolete • Fragile tungsten element • Being phased out by the UK government

Tungsten Halogen	Pros	Cons
A development from the GLS lamp, the tungsten element is mixed with a halogen gas to improve light output. Integrated into reflective housing, or a bare lamp that requires a reflector.	• Brighter than GLS • Inexpensive and readily available • Instantaneous light • No gear required • Excellent colour rendering • Lamps can have integrated reflectors • Low capital cost • Adds sparkle to interior	• High operating temperature • High running costs • Transformer may be required • Short lamp life, 2000-5000 hours

Compact Fluorescent	Pros	Cons
Compact fluorescent lamps, CFLs, are ideal for providing general and background illumination. Only suitable replacements can be used.	• Inexpensive & easily available • High efficiency • Variety of colour temperatures • Short warm up time • Can be dimmed • Used for emergency lighting • Good colour rendering • Long lamp life • Low operating temperature	• Lower colour rendering than halogen source • Requires control gear

Linear Fluorescent

Linear and circular fluorescent lamps are one of the most efficient light sources. Excellent value for money/light output. The light distribution can be controllable via use of reflectors and optics

Pros

- Inexpensive & easily available
- Excellent efficiency
- Various colour temperatures
- Short warm up time
- Can be dimmed
- Used for emergency lighting
- Excellent colour rendering
- Long life versions available
- Low operating temperature

Cons

- Lower colour rendering than halogen source
- Requires control gear
- T5 lamps can be unstable if used outdoors
- Generally large luminaires

High Intensity Discharge

Produces high light output for its size. A point source that requires a reflector to control the light distribution. Generally used for spot and accent lighting

Pros

- Excellent efficiency
- Variety of colour temperatures
- Used internally and externally
- Excellent colour rendering
- Lamp life = 12-15,000 hours
- Low-mid operating temperature
- Special colour spectrum lamps available
- Small in size

Cons

- Non instantaneous light
- Once switched off needs to cool before re-striking
- Requires control gear
- No emergency lighting
- More expensive than halogen

LEDs

LEDs are the latest development in lighting and are classed as solid state lighting. No replaceable lamp element, the silicon chip that illuminates is part of an electrical circuit. Life expectancy has a significant effect on maintenance costs i.e. a reduction.

Pros

- Long life, 30-50,000 hours
- Low surface/beam temperature
- No UV light output
- Range of colours/colour temperature
- Easily controllable
- Can be used both internally/ externally
- No lamp reduces maintenance
- Used for emergency lighting
- Instantaneous light
- Fast developing technology

Cons

- Whole fitting needs to be replaced when fails
- Requires specific driver
- LEDs require heat sinks, else will start to fail
- Colour rendering can be poor

5.0 *Lighting Design Guide*

5.5 Lighting Methods

Developments in LED technologies are advancing exponentially and fit out designers should interrogate the market place accordingly to examine all opportunities for utilising the technology within their designs.

Adjustable Downlights

Common Practice

Provide a simple, effective, flexible solution for display lighting.

Tungsten halogen are commonly used lamps for these fitting types.

These provide an efficacy of 20-25lm/W

Best Practice

The same visual appearance can be achieved with the use of metal halide lamps. They provide a much higher output for less energy and have a significantly longer lamp life.

These provide an efficacy of >80lm/W

Downlights

Common Practice

Simple fixed downlights are a common type within retail applications.

The light distribution from a halogen downlight is often tight and focused.

Best Practice

Compact Fluorescent downlights offer a more ambient distribution that can be controlled with attachments and reflectors.

Downlights that use a discharge source can achieve a range of beam angles.

Adjustable Downlights

Common Practice

Tungsten halogen are the common lamp for these fitting types.

These provide an efficacy of 20-25lm/W

Best Practice

The same visual appearance can be achieved with the use of metal halide lamps.

These provide an efficacy of >80lm/W

Feature Pendants

Traditionally, pendants use GLS or tungsten halogen lamps.

These provide an efficacy of 15-17lm/W

Best Practice

Compact fluorescent or discharge lamps provide a low energy equivalent.

These provide an efficacy of 60-80lm/W

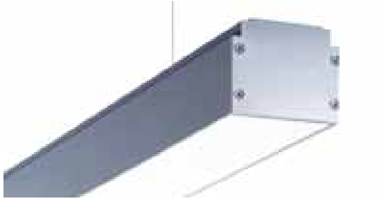
5.0 Lighting Design Guide

5.5 Lighting Methods

Linear Fluorescent

Common Practice

Fluorescent lighting can provide high illuminance levels very efficiently. The output of the selected luminaires can significantly affect this though, so careful selection needs to be considered.

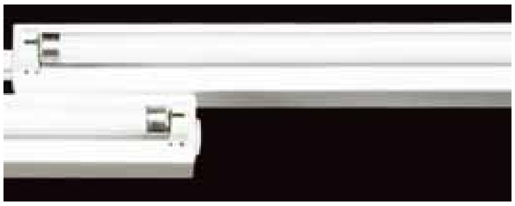


Concealed Lighting

Common Practice

Concealed lighting allows for either a subtle wash, or dramatic effect to be applied to a surface without seeing the brightness of the light source.

This effect can be achieved using linear fluorescent battens, cold cathode or LED systems. LED units allow simple colour changing within the outlet.



5.0 *Lighting Design Guide*

5.6 Illustrative Examples

5.6.1 Models

A model has been built of a particular space and is used to illustrate some current lighting design approaches and compare it against a direct replacement for energy efficient light sources.

Three scenarios are compared:

1. Common practice, taken from actual retail designs
2. A like for like, lamp replacement scheme where performance figures are comparable
3. A revised lighting scheme, meeting most of the original design aspirations

Wherever a raft mounted spotlight has been used, for the purpose of calculation and comparison they are orientated so that they project straight down onto the floor.

5.6.2 Controls

The affect of basic controls are also considered in the final assessments based upon the following assumptions;

1. Retailers trade as follows:

- 362 days per year
- 7 days per week
- Trading 9.00am to 8.00pm Monday to Saturday
- Trading 10.00am to 4.00pm Sundays and Bank Holidays
- Restocking/servicing 7.00am to 9.00am and 8.00pm to 10.00pm Monday to Saturday

2. Three levels of control are provided as follows:

- Shop front to utilise solar time switch which is 'active' 8.00am to 1.00am
- Back of house lighting is PIR controlled
- During restocking/servicing periods, lighting levels are halved

5.0 *Lighting Design Guide*

5.7 Example 1: Large Retail Unit 825m²

5.7.1 A large brand retail outlet with the main shopping area split over two floors.

Each floor incorporates:

- The main consumer space
- Changing rooms
- Back of house areas
- Window displays

The first floor houses:

- The main stock room
- Staff room and staff WC's

5.7.2 Common Practice Design Approach

- The majority of the spaces lit with halogen spotlights mounted to a suspended raft
- The changing rooms are lit using a combination of linear fluorescent and halogen downlights
- Back of house areas are lit with T8 linear fluorescent and CFLs.
- The window displays are lit using a combination of halogen and LED spotlights
- Separate fluorescent emergency units

5.7.3 Common Practice Design Commentary

- Low Uniformity throughout the space
- Heat from halogen source likely to increase need for a/c
- Poor vertical illuminance at cashier desk could make it difficult to identify
- Poor vertical illumination throughout
- Changing room illuminance levels low
- WC's are under lit
- Stock room floor over lit
- Vertical planes of stock area too low
- Short lamp life will result in high maintenance costs

Low W/m² misleading as many areas not lit to required standard.

Fig.3 Base Model

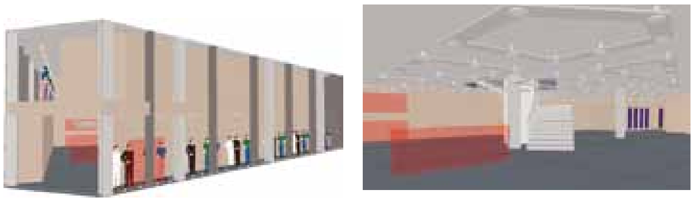


Fig.4 Common practice visualisation

Fig.5 Common practice light fittings

5.7 Example 1: Large Retail Unit 825m²

5.7.4 Energy Efficient Replacement

To illustrate the instant benefit of using lamps with a high lumen efficiency, fittings have been replaced with the closest matching efficient alternative. In most cases the fitting is available with multiple lamp options and it is a straight swap.

- 75W Halogen spots in window switched with 20W CDM
- 75W Halogen spots in main sales area switched with 20W CDM
- 50W Halogen downlights in changing rooms switched with 20WCDM
- 4x18W T8 modular fitting in staff room switched with 3x14W T5 fitting
- 2x70W T8 fitting in stock room switched with 2x35W T5 fitting

Where the fittings are replaced, the newer luminaire may have a light output ratio that varies from the original fitting.

5.7.5 Energy Efficient Replacement Commentary

- Most areas illuminance levels increased
- Stock room levels dropped, but are still within the requirements
- Lumens/Watt increased by 300%
- Watts/m² reduced by more than 50%

5.7.6 Alternative Lighting Design Approach

- CDM spotlights and direct/indirect linear fluorescent in main sales area
- Recessed CFL wall washers highlighting vertical planes
- CDM spotlights and linear LED projectors in window display
- CDM and linear fluorescent fittings in changing rooms
- Cashier desks, changing rooms and stair edges highlighted using LEDs
- Suspended CDM modules placed between raft systems adding further illumination and highlights
- High efficiency linear fluorescent used in back of house areas

5.7.7 Alternative Lighting Design Commentary

- Reduction of contrast whilst still achieving visual interest
- Use of PIR and daylight sensors in back of house areas would increase savings
- Overall reduction in fittings and lamps
- Longer life lamps reduces maintenance costs
- Reduction in power consumption from original design whilst increasing illuminance levels
- Improved vertical illumination throughout
- Low W/m² whilst achieving required illuminance levels
- Overall cost of fittings is reduced with an overall improved lit impression
- When compared with the original design:
- Lumens/Watt increased by 284%
- Watts/m² reduced by 56%

Fig.6 Energy Efficient Replacement Visualisation

Fig.7 Alternative 'Equivalent' Design Visualisation

5.0 *Lighting Design Guide*

5.7 Example 1: Large Retail Unit 825m²

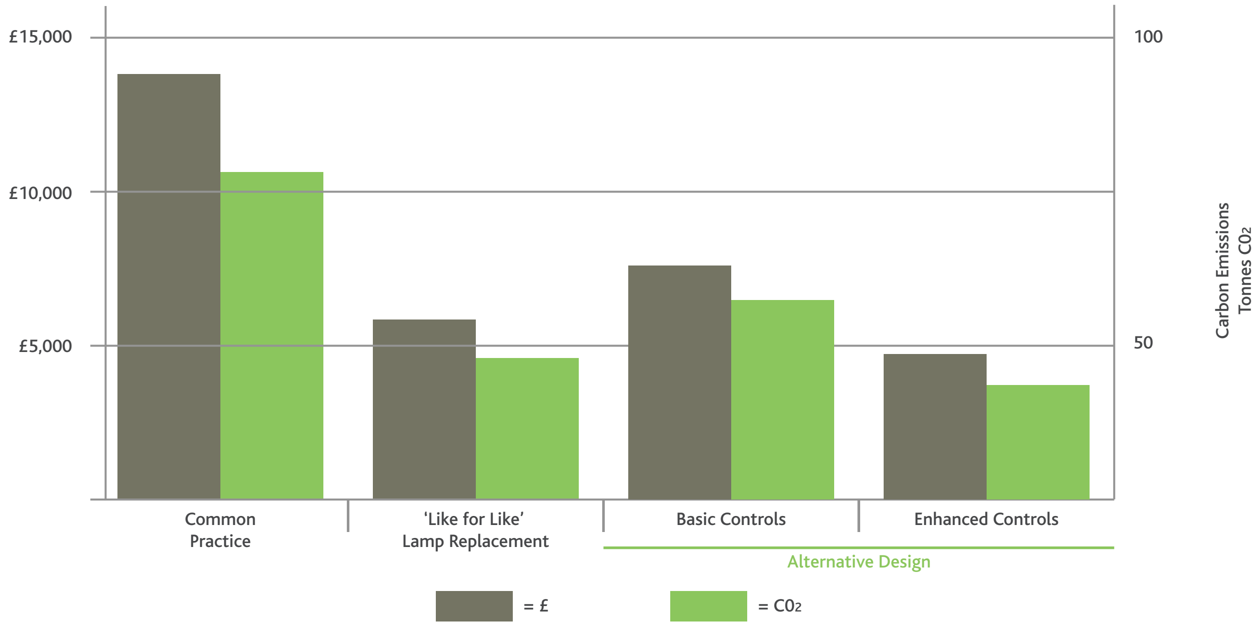
5.7.8 Scheme Comparisons

The tables below provide a direct indicative comparator of each scheme design solution highlighting, in particular, the energy consumption, energy cost and equivalent carbon emissions for each.

Fig.8 Energy and Cost Comparisons

	Common Practice	Energy Efficient Replacement	Alternative Design Solution	
			Basic Controls	With Enhanced Controls
Watts (W)	31,500	11,609	14,211	14,211
Lumens (Lm)	434,079	488,019	753,911	753,911
Lumens/Watt (Lm/W)	14	42	53	53
Watts per Metre Squared (W/m²)	38	14	17	17
Number of Fittings	397	397	392	392
Number of Lamps	538	538	476	476
Cost of Fittings (£)	£70,726	£74,262	£70,189	£70,189
Annual Energy Consumption (kWh)	159,667	58,847	72,037	52,939
Annual Energy Cost[1] (£)	£13,573	£5,002	£6,123	£4,500
Annual Carbon Emissions[2] (Tonnes CO_2)	67	25	30	22

1 Energy Costs based upon 8.0p/kWh
2 Carbon Emissions based upon 0.422kgCO_2/kWh



5.7 Example 1: Large Retail Unit 825m^2

Fig.9 Illuminance Comparisons

	Average Illuminance Level (lux)		
	Common Practice	Energy Efficient Replacement	Alternative Design Solution
Window Display	127	145	329
Ground Floor Sales	270	322	760
First Floor Sales	272	331	551
Ground Floor Sales Vertical 1	47	67	223
Ground Floor Sales Vertical 2	59	72	292
Cashier Desk Front	58	63	219
Cashier Desk Horizontal	340	403	529
Cashier Logo Wall	42	50	522
Changing Room	500	598	598
Staff Room	200	277	277
Stock Room Floor	370	263	240
Stock Room Vertical	241	165	150

5.0 *Lighting Design Guide*

5.8 Example 2: Medium Retail Unit 400m²

5.8.1 Common Practice Design Approach

- The majority of the space is lit with halogen downlights
- The entrance space is lit using suspended adjustable metal halide spotlights, complimented by a decorative pendant using a 100W GLS lamp
- Walkway areas are highlighted using recessed metal halide spotlights
- Pelmet section in the centre of the shop space is highlighted using T5 linear fluorescents, hidden from view
- Dichroic halogen downlights provide illumination on the sales counter
- The changing rooms are illuminated using linear fluorescents
- The toilets are illuminated using a surface mounted opal CFL fitting
- The back of house areas and office are lit using a T5 linear fluorescent with an opal diffuser
- Separate emergency LED units

5.8.2 Common Practice Design Commentary

- Main sales area over lit
- Poorly positioned downlights light the floor rather than the shelves
- Heat from halogen source likely to increase need for a/c
- Cashier desk over lit, poor vertical illuminance could make it difficult to identify
- Poor vertical illuminance throughout
- Changing room illuminance levels too low
- Contrast between sales area and changing rooms too great
- WC's, stock area, office and stairwell are under lit
- Vertical planes of stock area too low
- Low W/m² misleading as many areas not lit to required standard

Fig.10 Common Practice Visualisation

5.8 Example 2: Medium Retail Unit 400m^2

5.8.3 Energy Efficient Replacement

To illustrate the instant benefit of using lamps with a high efficacy, fittings have been replaced with the closest matching efficient alternative. In most cases the fitting is available with multiple lamp options and it is a direct replacement.

- 50W Halogen spots in main sales area switched with 20W CDM
- 35W T5 back of house fitting switched with 35W T5 fitting with improved efficiency

Where the fittings are replaced, the newer luminaire may have a light output ratio that varies from the original fitting.

5.8.4 Results

- Most areas illuminance levels increased
- Ground Floor Lumens/Watt increased by 104%
- First Floor Lumens/Watt increased by 105%
- Ground Floor Watts/m^2 reduced by 44%
- First Floor Watts/m^2 reduced by 18%
- Capital cost increased by 25%

Note: Fig.10 and Fig.11 demonstrate that energy efficient replacement lighting makes no difference to the visual look of a unit.

Fig.11 Energy Efficient Replacement Visualisations

5.0 Lighting Design Guide

5.8 Example 2: Medium Retail Unit 400m^2

5.8.5 Alternative Lighting Design Approach

- 3 circuit track with CDM spotlights highlighting windows and shelving
- Recessed CFL downlighters, also used for emergency lighting
- Linear fluorescent wall washing and uplighting
- Integrated fluorescent lighting within central shelving units
- Cashier desk front and logo highlighted using LEDs and linear fluorescent fittings
- The changing rooms illuminated with recessed linear fluorescent fitting
- High efficiency linear fluorescent used in back of house areas.
- Office and stock shelving areas lit using direct/indirect linear fluorescent
- LED fittings used to add feature colour to centre of pelmet detail

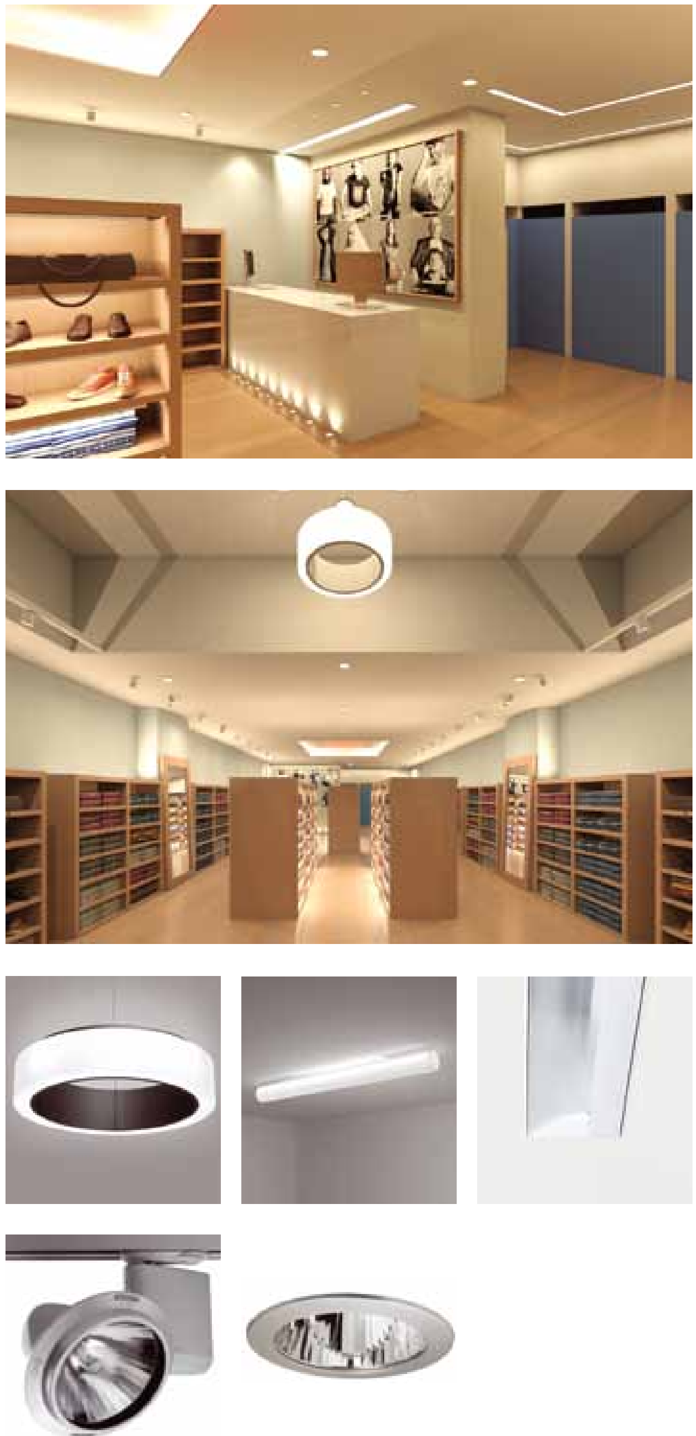
5.8.6 Alternative Lighting Design Commentary

- Reduction of contrast whilst still achieving visual interest
- Use of PIR in back of house areas would increase savings
- Overall reduction in fittings and lamps
- Longer life lamps reduces maintenance costs
- Reduction in power consumption whilst increasing illuminance levels
- Improved vertical illumination throughout
- Low W/m^2 whilst achieving required illuminance levels

5.8.7 Results

- Ground Floor Lumens/Watt increased by 125%
- First Floor Lumens/Watt increased by 89%
- Ground Floor Watts/m^2 reduced by 54%
- First Floor Watts/m^2 reduced by 7%

Fig.12 Alternative Lighting Design Visualisations



5.8 Example 2: Medium Retail Unit 400m²

5.8.8 Scheme Comparisons

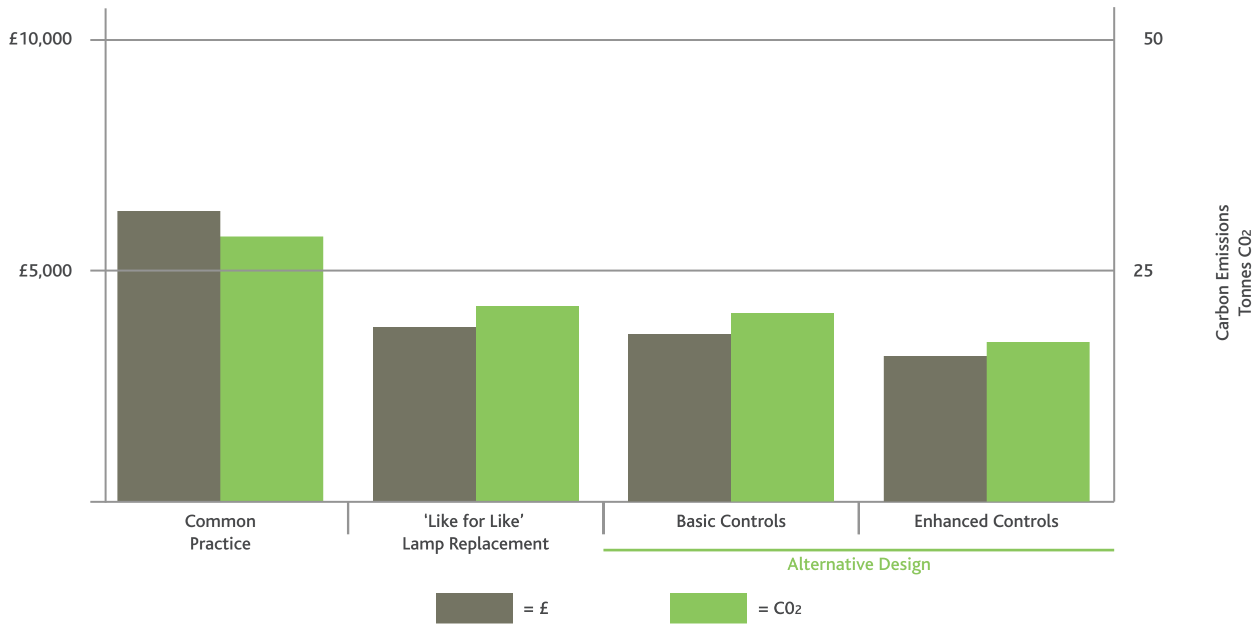
The tables below provide a direct indicative comparator of each scheme design solution highlighting, in particular, the energy consumption, energy cost and equivalent carbon emissions for each.

Fig.13 Energy and Cost Comparisons

	Common Practice		Energy Efficient Replacement		Alternative Design Solution		With Enhanced Controls
	Ground Floor	First Floor	Ground Floor	First Floor	Ground Floor	First Floor	
Watts (W)	12,419	1,704	6,884	1,480	5,701	1,613	7,314
Lumens (Lm)	299,478	62,250	338,048	112,753	310,283	113,983	113,983
Lumens/Watt (Lm/W)	24	37	49	76	54	70	124
Watts per Metre Squared (W/m²)	73	7.5	41	6.2	34	7	41
Number of Fittings	270	38	270	38	204	42	246
Number of Lamps	278	38	278	38	204	42	246
Cost of Fittings (£)	£20,004	£1,900	£22,534	£5,045	£19,569	£4,759	£24,328
Annual Energy Consumption (kWh)	71,591		42,397		37,076		27,246
Annual Energy Cost[1] (£)	£6,085		£3,603		£3,151		£2,316
Annual Carbon Emissions[2] (Tonnes CO_2)	30		18		16		12

1 Energy Costs based upon 8.0p/kWh

2 Carbon Emissions based upon 0.422kgCO_2/kWh



5.0 *Lighting Design Guide*

Fig.14 Illuminance Comparisons

	Average Illuminance Level (lux)		
	Common Practice	Energy Efficient Replacement	Alternative Design Solution
Window Display	127	145	329
Sales Floor	1,310	1,550	610
Shelving	68	58	220
Cashier Desk	1,050	1,490	400
Logo Wall	120	151	657
Changing Room	53	54	93
Ground Floor Back of House	90	135	102
Stock Room Floor	79	125	161
Stock Room Shelving	51	86	90
Office	66	98	228

Low Energy Design Guides

Air Conditioning

6.0 *Air Conditioning Design Guide*

6.1 Introduction

Heating, ventilation and air conditioning systems within retail units can account for up to 50% of the tenant's energy bill.

By adopting good practice methods to the air conditioning system design and operation savings of up to 20% can be achieved.

Improving the energy efficiency of the air conditioning system will contribute towards improving the Energy Performance Certificate (EPC) rating, Building Energy Rating (BER) and BREEAM rating, where applicable.

This section identifies ways to reduce energy consumption by optimising air conditioning selection and operation.

6.2 Guidance Notes

This section provides guidance on achieving the most efficient air conditioning system.

6.2.1 Size the System to Suit the Actual Load

The more heat is released into the shop unit the more air conditioning capacity is required. The higher the electrical load in the space the higher the air conditioning load. Sizing the air conditioning system capacity to match, rather than substantially exceed, the loads in the space being treated will result in lower costs and more efficient operation.

The following guidelines cover the sizing of the air conditioning system:

- Significantly over-sizing the air conditioning system results in higher capital and operating costs and therefore care should be taken during the system design to use accurate figures
- Reduce electrical loads in the space such as lighting as this will also reduce the size of the required air conditioning system – for further information refer to the section in this guide on lighting design
- Any reductions in electrical load must be taken into account in the sizing of the air conditioning system i.e. the air conditioning designer must be made aware of any electrical load reductions
- Using rules of thumb, or previous shop unit capacities, to size the air conditioning systems should be avoided - The system should be sized to suit the actual shop unit into which the system will be installed
- Simply adding all peak loads together to obtain the peak air conditioning load can result in system over-sizing – consideration should be given to when individual peak loads occur i.e. peak external ambient (outside air) conditions will occur in summer whilst peak occupancy (people) loads is likely to occur during the Christmas period
- Solar shading to shop-fronts will reduce solar gains within the shop unit and should be considered during the design stage, where possible
- Design occupancy levels should not exceed 1 person per $5m^2$ (rather than means of escape figures which may be a higher density than this)
- The load imposed on the space by ventilation systems should be taken into account – for further information refer to the section in this guide on ventilation

“Ensure that air conditioning run times match occupancy times to save energy.”

6.2.2 Operate the System to Minimise Energy Consumption
The operation of the air conditioning systems should be automatically controlled to satisfy the required temperatures for the required occupied hours.

Ideally plant should be controlled centrally so that all equipment can be easily set or adjusted if the need arises.

Air conditioning run-times should be minimised as much as possible. The operating times should be set to match the occupancy and usage hours of the retail unit.

Operating the air conditioning after-hours should only be done if absolutely necessary. The room will maintain its temperature for some while after the plant is switched off automatically.

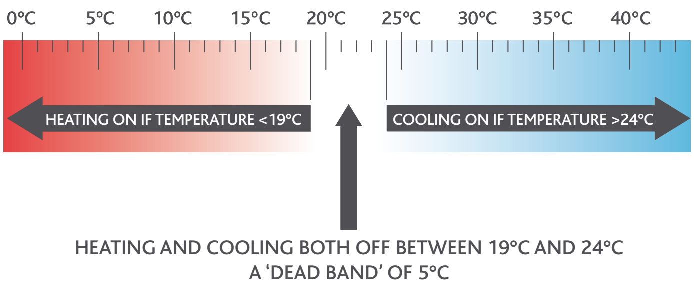
The operation of the heating mode should only be activated once the temperature in the space drops to 19°C. Whilst the cooling mode should only be activated once the temperature rises to 24°C in the space.

This is known as the ‘dead-band’ and effectively prevents systems operating in heating and cooling mode at the same time. The wider the dead-band the more energy will be saved. Occupant comfort has to be considered when widening the dead-band beyond the figures mentioned.

Windows and doors in air conditioned areas should be kept closed at all times. This should include closing doors to adjacent un-conditioned areas.

When rooms are unoccupied the air conditioning should be switched off.

Fig.15 Diagram of ‘dead band’ control providing recommended temperatures (Source: The Carbon Trust – CTV001)



“Failure to maintain plant can increase energy consumption by 60%.”

6.2.3 Maintain the System to Ensure Optimum Performance
Energy consumption can increase by up to 60% if regular maintenance is not undertaken.

A maintenance contract should be entered into to ensure that manufacturer’s recommended maintenance is carried out at regular intervals by trained technicians. This will ensure that the performance of the system is keep at its optimum.

6.2.4 Setting Targets
Knowing the amount of energy an air conditioning system would consume in a good practice installation will allow targets to be set both at plant selection and ongoing performance.

A target of 150 kWhs per square metre a year for total electrical energy (including air conditioning) is a benchmark target that should be aspired to.

This figure includes all energy consumed within a retail application and will vary depending on the particular application.

6.2.5 Monitoring Energy Consumption
Metering should be applied where possible to identify the energy consumed by the air conditioning system. This allows energy consumption to be monitored and performance targets to be set. Awareness of the costs will increase the focus on reducing the energy consumed.

Energy usage can be monitored by type (such as lighting, air conditioning, small power etc.) by recording electricity use on main electrical circuits. Intelligent meters can be used so that trends and peaks can be viewed.

6.2.6 Energy Reduction Management
Retailers have found that including a store’s energy performance within the manager’s performance assessment, together with an employee awareness scheme, has achieved a 20% reduction in energy costs in the first year. By regularly monitoring and reporting energy consumption the awareness of employee’s can be raised to the improvements that can be achieved by simple working practices.

Collaboration between the landlord and the tenants management teams, by sharing information, can be an effective method by which energy usage can be monitored and reduced.

“First year savings of up to 20% are achievable by increasing staff awareness.”

6.0 *Air Conditioning Design Guide*

6.3 System Selection

Energy efficiency can be improved and energy costs reduced by selecting an appropriate air conditioning system type.

"Air cooled VRF systems can be up to 30% more efficient that split systems."

A number of system options exist for retail units:

- Split a/c units
- Variable refrigerant flow (VRF)
- Fan coil units

The available system type will depend on the type of retail unit and any provisions made by the landlord. The choice will be determined to a large degree as to whether the tenant has their own plant space or not.

A typical 250m^2 shop unit on an air conditioned mall was simulated to determine the performance of each type of system. The results are shown below (figures are per annum).

Fig.16 Performance Comparison Of Air Conditioning Systems In Simulated 250m^2 Retail Unit

System	Split System	Air Cooled VRF [1]	Water Cooled VRF	Fan Coil Unit [2]
Control	Local Only	Good	Good	Excellent
Heating COP	3-4	3-5	3-6	Boiler 85%
Cooling COP	3-5	6-8	3-5	Chiller >3
Capital Cost [3]	£7,750	£11,800	£14,000	£18,500
Maintenance Cost	£500	£700	£700	£900
Running Cost [4]	£700	£500	£770	£700
CO_2 Emissions [5]	3700 kg	2700 kg	4050 kg	3700 kg

1 The information provided in the table above relating to the split systems is for comparison only. When the tenant has a rooftop plant area for external condensers the air cooled VRF should be used. Split systems should not be used as they have poor energy and carbon performance in comparison with air cooled VRF.

2 The figures for the fan coil unit system is for conventional generation of heating and chilled water (gas boilers and electric chillers). These figures could be improved with the use of CHP (combined heat and power) and/or absorption chillers (Trigeneration) to provide a lower carbon solution.

3 Capital cost figures are for installation within the shop unit only and excludes cost of landlords systems i.e. it excludes such items as plate heat exchangers.

4 The running costs have been based on tariff rates of 8 pence/kWh for electricity and 4.5 pence/kWh for gas.

5 The carbon content that has been used is for electricity 0.422 kgCO_2/kWh and for gas 0.194 kgCO_2/kWh.

The figures in the above table are reported more fully in the Air Conditioning Comparison.

6.0 *Air Conditioning Design Guide*

6.3.1 Split Systems

Split systems are a basic air conditioning system with indoor units to condition the space and external units to reject heat.

Split systems are often used where a tenant is provided with their own external plant space. Split systems, whilst being relatively low cost to install, produce higher levels of carbon emissions than other forms of air conditioning. This type of system is no longer in favour due to its poor energy and carbon performance.

Benefits:

- Low cost solution
- Contractors familiar with system design and installation

Disadvantages:

- High carbon emissions
- Poor energy efficiency
- No heat recovery
- External unit needs to be located close to shop unit
- Does not allow simultaneous heating and cooling
- Local control only
- Poor air distribution

6.3.2 Air Cooled VRF

VRF systems are more advanced than split systems in that they provide better control and performance by varying the flow of refrigerants through the system.

Air cooled VRF systems can be used where a tenant is provided with their own external plant space. Air cooled VRF systems provide a good solution as they are energy efficient and produce lower carbon emissions than split systems.

Benefits:

- Good control
- Heat recovery available
- Energy efficient
- Lower carbon emissions
- Allows simultaneous heating and cooling
- Contractors familiar with system design and installation
- External unit can be positioned a good distance away from the shop unit

Disadvantages:

- More expensive than simple split systems
- Can achieve good air distribution but careful design required

Fig.17 Typical Split System Air Conditioning Layout

Fig.18 Typical Air Cooled VRF Air Conditioning Layout

6.0 *Air Conditioning Design Guide*

6.3.3 Water Cooled VRF (connected to Landlords Condenser Water Loop)

Water cooled VRF systems can be used where a tenant does not have their own external plant space. These units are used where the landlord provides a connection to the centre's condenser cooling water (CCW) system into which the tenant rejects heat and, where allowable, draws from it heat for winter heating. This system would be adopted where there is limited roof space or where shop units are landlocked. A heat exchanger is installed between the landlords and tenants CCW systems to prevent the risk of cross-contamination/loss of water volume. Water cooled VRF systems provide a good solution as they offer heat recovery but the basic system produces higher carbon emissions than an air cooled VRF system.

Benefits:

- Good control
- Heat recovery available
- Allow simultaneous heating and cooling
- Installation is contained within unit
- Lower refrigerant system volume than air cooled condenser systems
- Performance of this system can be enhanced (lower carbon and energy) if landlords' energy centre employs low to zero carbon technology

Disadvantages:

- More expensive than air cooled VRF
- Careful air distribution design required
- Retailers need to be familiar with requirements to connect to a condenser cooling water system
- System capacity is often limited by connection size provided by landlord
- Reliance on performance of landlords CCW system

6.3.4 Fan Coil Unit

Fan coil units use heating and chilled water to condition the space.

Fan coil unit systems can be used where a landlord provides a tenant with heating and chilled water connections fed from centralised plant. This arrangement allows the use of low to zero carbon technologies such as biomass boilers, combined heat and power (CHP) units or absorption chillers in the landlords energy centre. A heat exchanger is installed between the landlords and tenants systems to prevent the risk of cross-contamination/loss of water volume. This system may be adopted to satisfy local planning requirements for a renewables contribution to on-site energy use.

Benefits:

- Good control
- Good air distribution
- Installation is contained within shop unit
- Performance of this system can be enhanced (lower carbon and energy) if landlords' energy centre employs low to zero carbon technology

Disadvantages:

- No heat recovery
- Expensive installation
- M&E designer required rather than an A/C designer

Fig.19 Typical Water Cooled VRF Air Conditioning Layout

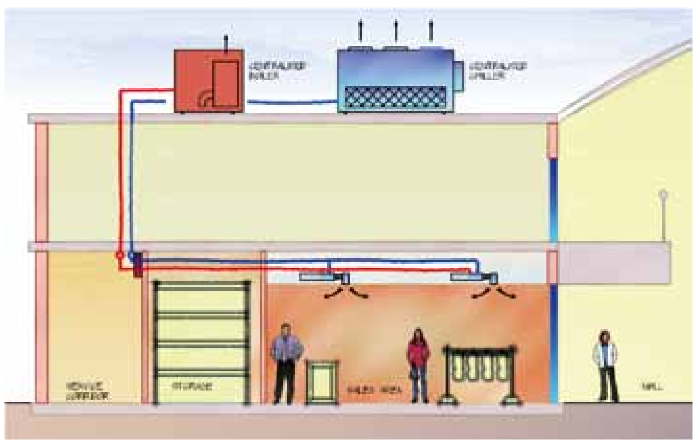


Fig.20 Typical Fan Coil Air Conditioning Layout

6.4 Overdoor Heaters

Overdoor heaters can provide an effective barrier across shop doors where a shop unit faces onto an area that in winter could be at a lower temperature than the shop itself. Overdoor heaters can be designed to limit and offset the effect of cooler air entering the shop unit.

Tenants should consider keeping shop front doors closed during periods of extreme cold and heat as air entering the shop unit during these periods will impose significant heating /cooling loads on the shops systems.

If a VRF system is being used in the shop unit then it is possible to utilise an overdoor heater connected to the same system. An overdoor heater connected to a VRF system will have much lower running costs and generate far less carbon then an electric overdoor heater. The reduction in running costs and carbon can be as much as 65%.

A comparison of the different types of overdoor heater available is shown in the table below:

Fig.21 Comparison Of Overdoor Heater Units

Overdoor Heater Type	Electric	LPHW Heating	VRF
Capital Cost 1	£1,150	£1,100	£4,750
Running Cost 2	£350	£230	£90 [4]
CO_2 Emissions 3	1850 kg	1000 kg	460 kg [4]

1 Capital cost figures are for the overdoor heater only, excluding the heat source and interconnecting pipework/cabling.

2 The running costs have been based on tariff rates of 8 pence/kWh for electricity and 4.5 pence/kWh for gas.

3 The carbon content that has been used is for electricity 0.422 $kgCO_2/kWh$ and for gas 0.194 $kgCO_2/kWh$.

4 A heat recovery VRF system would likely reduce this figure close to zero as units towards the rear of the shop would likely be in cooling all year round. The heat removed from the rear of the unit could be discharged over the doors.

Low Energy Design Guides

Ventilation

7.0 Ventilation Design Guide

7.0 Introduction

Fresh air ventilation is essential for providing a quality environment for shoppers and employees.

"Using the correct fresh air supply rate can save up to 50% in energy consumed."

Due to the large variance in the number of people within a retail outlet across the year fresh air volumes can be lower than in other applications such as offices.

The fresh air requirement imposes a heating and cooling load on the space across the year, therefore, ensuring that the optimum amount of air is supplied will ensure energy is not wasted.

7.1 Common Practice

Currently retail tenants tend to install ventilation systems without any heat recovery or variable speed control to allow the system to respond to varying demands.

7.2 Guidance Notes

This section provides guidance on achieving the most efficient ventilation system.

7.2.1 Use the correct air volume

Fresh air for occupants is reduced for retail units on the basis that there is a high degree of variance across the day/year in the number of people in the unit.

Approved Document F of the Building Regulations references the Chartered Institute of Building Services Guides for the required fresh air ventilation rate. The rate required for retail units is set at 1 litre/second per m^2.

"Fresh air should be provided at a the rate of 1 litre per second per square metre of floor area."

Sometimes a centralised ventilation system will be provided for connection to by the tenant. The volume rates will be detailed in the tenant's handbook for each particular project.

Fig.22 Typical Fresh Air Ventilation Layout

7.2.2 Size the Fans to Reduce Energy Consumed

The energy used in moving air through the ventilation system is now limited by the Building Regulations.

Ensuring that the fans are selected to meet or exceed these values will mean that energy required to continually run the fans is minimised.

7.2.3 Use Variable Speed Drives

Where possible variable speed drives should be fitted to fans so that the speed can be varied to suit the demand for ventilation.

"Variable speed drives can save between 25-40% of energy consumed by fans."

One way this can be achieved is by using sensors in the space that monitor air quality and vary the fan speed depending on the need for fresh air. This results in less air being supplied, and hence energy saved, when there are fewer people in the space.

DC motors, rather than AC motors, should be considered on fan systems (particularly fan coil units) as these offer energy saving benefits.

7.2.4 Recover Energy from Extract Systems

Where air is extracted from the space then a heat recovery unit should be fitted so that energy can be recovered and used in the supply air.

"Heat recovery units have efficiencies up to 90%"

Heat recovery units can recover 50-90% of the available energy in the extract air.

Heat recovery can be achieved in a number of ways – by minimising fresh air and recirculating air to suit occupancy levels, by installing a recuperator or by installing a run-around coil.

The recovery of energy from the extract air will also reduce down the load on the air conditioning plant.

Fig.23 Cost and Emission Benefits of Heat Recovery

System	Without Heat Recovery	With Heat Recovery
Running Cost [1]	£620	£140
CO_2 Emissions [2]	3250 kgs	725 kgs

1 The running costs have been based on tariff rates of 8 pence/kWh for electricity and 4.5 pence/kWh for gas.

2 The carbon content that has been used is for electricity 0.422 $kgCO_2$/kWh and for gas 0.194 $kgCO_2$/kWh.

7.3 Operate the System to Minimise Energy Consumption

The operation of the ventilation systems should be automatically controlled to satisfy the required temperatures for the required occupied hours.

"Ensure that ventilation run times match occupancy times to save energy."

Ideally plant should be controlled centrally so that all equipment can be easily set or adjusted if the need arises.

Plant run-times should be minimised as much as possible. The operating times should be set to match the occupancy and usage hours of the retail unit.

Operating the ventilation after-hours should only be done if absolutely necessary.

7.4 Maintain the system to ensure optimum performance

Energy consumption can increase by up to 60% if regular maintenance is not undertaken.

A maintenance contract should be entered into to ensure that manufacturers recommended maintenance is carried out at regular intervals by trained technicians. This will ensure that the performance of the system is kept at its optimum.

Low Energy Design Guides

Restaurant & Kitchen

8.0 Restaurant & Kitchen Design Guide

8.0 Introduction

This section presents current guidance and innovations aimed at reducing energy consumption by good practice design of kitchen ventilation systems and canopy design.

8.1 Trends in Kitchen HVAC

8.1.1 Design

Kitchen ventilation systems are fundamental for controlling health and safety risks in kitchens, in addition to creating a safe and comfortable working environment by providing adequate ventilation.

The requirements can be summarised as:

- To introduce clean air and remove excess hot air
- To provide sufficient air for complete combustion and maintain acceptable carbon monoxide levels
- Dilute and remove odours, vapours and steam from cooking processes

However, in meeting the above requirements, a significant proportion of the kitchens overall energy consumption can be attributed to the ventilation system.

Cooking processes use a lot of energy and creates heat, which must be removed and replaced with an adequate supply of air. Also, ventilation systems tend to operate at full capacity during occasions when the equipment is not fully utilised. As a consequence kitchen ventilation systems consume a large amount of energy.

The ventilation system design must take account of the following:

- Type of cooking activities
- Fuels to be used in cooking
- Type and amount of cooking equipment
- Requirements for grease removal before final discharge
- The layout of the kitchen
- The need for safety interlocks and fire suppression
- Proximity of neighbouring properties

Often due to a desire to standardise equipment procurement, the specification of ventilation equipment is based on previous schemes. This recycling of ventilation equipment specifications often results in excessively large extract volume safety margins and consequentially higher than necessary exhaust and supply air make-up rates. The effects of this over specifying generally go unnoticed. Such a system would remove heat and the products of combustion, while providing ample air for combustion appliances and occupants.

Additionally since restaurants rarely sub meter kitchen ventilation and cooling equipment the increases in energy costs are not highlighted.

8.1.2 Gas or Electricity

Gas has always been the preferred fuel for chefs and cooks because it is more responsive. However, gas hobs are responsible for most of the heat generated in kitchens, are often left on while not being used and require a physical interlock with the ventilation system.

Advances in electric induction technology, which generate less heat and turns off if the pot is taken away, can provide benefits across both capital and running costs as the high cost ventilation systems that gas supply requires will be dramatically reduced.

The below factors illustrate the benefit of adopting a recommended method of developing the design requirements.

8.1.3 Extract Canopies

Extract air can be removed from the kitchen space by either an extract canopy or ventilated ceiling, depending on the cooking fuel source. However, generally, where natural gas fuels are used and high temperature fume contaminants are produced within concentrated areas extract canopies or hoods are the most efficient.

The amount of air to be extracted from the space directly influences the size, and generally, the energy consumption of the extract fan. Therefore, it is always best to work closely with the specialist catering equipment supplier and calculate the extract air quantity by first understanding the air inlet requirements of specific appliances to be used. And not by simply using general advice on air changes alone. This will help to avoid over sizing the system or providing inadequate ventilation.

A commonly adopted Rule of Thumb method of calculating the required extract ventilation requirement suggests that it can be determined on the basis of achieving a face velocity of between 0.25 and 0.5m/s through the canopy.

An example of this is illustrated by considering an example using a recommended calculation method with that of the commonly used Rule Of Thumb.

Based on the opposite kitchen layout plan the canopy area has been determined (4410 x 1050mm) and applying a 0.4m/s face velocity results in a extract ventilation requirement.

Rule of Thumb approach (based on medium cooking duty)
- Extract Volume of 1.85m³/s

The below table outlines a recommended method of determining the extract ventilation requirement, defined within HVCA Specification for Kitchen Ventilation Systems – the recommended Thermal Convection Method.

Fig.24 Example kitchen and equipment layout

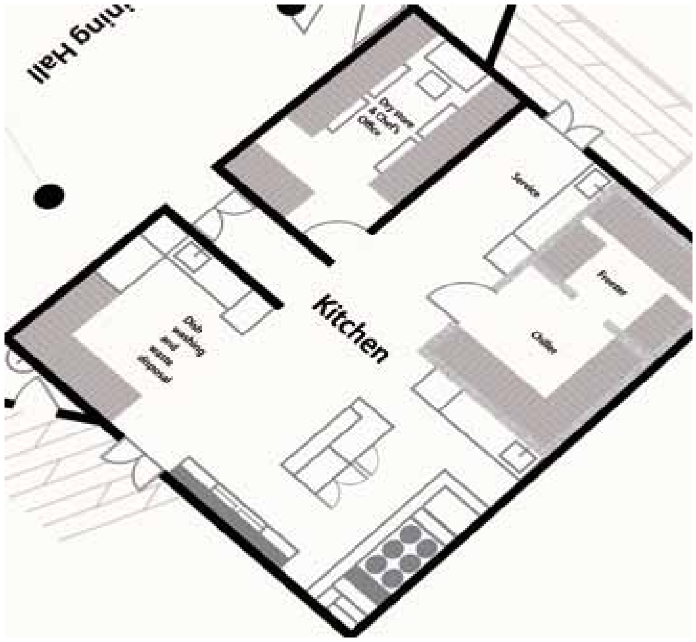


Fig.25 Recommended Extract Volume Calculation

Equipment	Fuel	Size	Area	Convection Coefficient	Flow Rate
Griddle	Gas	750 x 750	0.56	0.3	0.17
Bench	-	400 x 750	0.3	0.03	0.01
Range	Gas	900 x 750	0.68	0.35	0.24
Bench	-	400 x 750	0.3	0.03	0.01
Salamander	Gas	400 x 750	0.3	0.75	0.23
Twin Fryers	Electric	750 x 750	0.56	0.35	0.196
				Equipment Extract Flow Rate	**0.856**

- Adding a canopy factor - Extract Volume 1.07m³/s

8.0 Restaurant & Kitchen Design Guide

As can been seen from the above example, by using the Rule of Thumb method the extract volume can be approximately 55% over sized. The consequence of this on capital cost, resultant energy consumption and carbon dioxide emission is summarised within the next table.

Fig.26 Comparison of Extract Flow rate Calculation methods and impact on costs

	Common practice Rule of Thumb	Recommended method Equipment Details
Ductwork Cost	£13,739	£10,822
Fan Cost	£1,470	£1,300
Annual Energy Consumption	9,858kWh	7,229 kWh
Annual Energy Cost [1]	£788.64	£578.32p
Annual Carbon Emission [2]	4.2tCO_2	3.10tCO_2

1 Energy cost based on 8p/kWh
2 Carbon dioxide emission for electrical energy based on 0.422kgCO_2/kWh

The comparison table illustrates that using the rule of thumb method, an approximate increase in capital cost of 19% is probable, together with a 27% increase in annual running cost.

It should be noted that, in order to comply with The Gas Appliance Directive, manufacturers of catering equipment are required to provide details of corresponding specific air inlet requirements which need to be adhered to.

Ventilation requirements are also best specified as air velocities or volume flow rates into the canopy rather than, the commonly quoted, air change rates per hour.

8.1.4 Replacement air

Supply air to the kitchen, to replace combustion and extract air, should be delivered by a dedicated air handling unit. In order to keep the kitchen under negative pressure for odour control the supply system should be sized to provide approximately 85% of the extracted air volume, with the remaining 15% being drawn from adjoining areas. This arrangement keeps the kitchen space under negative pressure to help prevent the escape of odours.

In smaller kitchens sufficient replacement air can be drawn from the adjoining customer area space. Cooling or heating delivered via the adjacent space can provide some beneficial conditioning within the kitchen area.

It should be recognised increasing canopy extract rates also increase costs of make up air. This can be demonstrated using the previous example as follows:

Fig.27 Comparison of Replacement air provisions

	Based on 85% of estimated extract flow rate	Based on calculation using Equipment Details
Corresponding Replacement Air Volume (m^3/s)	1.49	0.83
Heating Coil Size (kW) (electric)	37 (kW)	21(kW)
Annual Energy Consumption	71,500kWh	41,200kWh
Annual Energy Cost [3]	£5,700	£3,300
Annual Carbon Emission [4]	30,170KgCO_2	17,380KgCO_2

3 Energy cost based on 8p/kWh
4 Carbon dioxide emission for electrical energy based on 0.422kgCO_2/kWh

The example above demonstrates total annual energy reduction of approximately 40%.

8.1.5 Local Authority Regulations and Landlord requirements
Local authority regulations relating to fire precautions, basement kitchens and smell nuisance to adjoining properties must be observed.

Land Securities also require tenants to take appropriate measures to minimise risk of causing nuisance to other tenants and generally require the inclusion of specialist filtration to remove grease and odours, prior to discharging externally at high level. It should be noted that the inclusion of a discharge cowl (often referred to as a Pitched Weather Cowl) is not recommended as they encourage down draughts and increase the potential of fumes re-entering the building.

An increasingly popular method of treating contaminated kitchen extract before discharge is to use ultra-violet (UV-C) filtration. Ultra Violet UV-C – is the latest technology for the efficient elimination of grease from within kitchen ventilation systems. The system combines cartridge filters and Ultra Violet UV-C light to provide grease and odour removal efficiencies in excess of 98%.

Airborne contamination is arrested at source and not conveyed by the ductwork system to atmosphere. Grease is prevented from entering the exhaust ductwork reducing fire risk and costly cleaning.

8.1.6 Opportunities for Heat Recovery
With the use of UV-C filtration, which virtually eliminates grease and prevents it entering the ductwork, the potential for incorporating heat recovery increases significantly. Recovered heat can be used to either heat supply air make-up during winter or to preheat a supply to the domestic hot water.

8.0 Restaurant & Kitchen Design Guide

8.2 Alternative methods of introducing make up air to complement kitchen extract systems

The type of Canopy and the systems effectiveness in maintaining good air quality is a major concern. The below examples provide guidance on implementation strategies, which are aimed at making the most of energy used while maintaining a good environment.

8.2.1 Kitchen Canopy – Influence of Make-up Air

Internal Supply

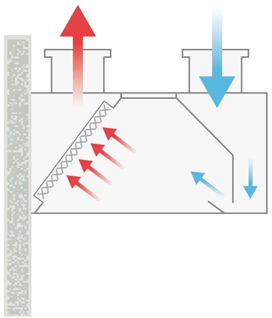
Generally not used, except when combined with other arrangements – such as air curtain and face discharge

Pros

- Can improve capture when used in conjunction with other strategies such as face discharge, which can lower the exhaust air flow volume

Cons

- Known to adversely affect the ability to capture the cooking fumes when used in isolation



Air Curtain

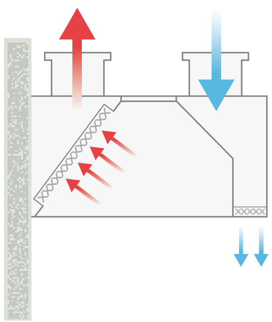
Generally not used in isolation, as the effect of introducing excessive supply air greatly reduces capture.

Pros

- Can improve capture when used in conjunction with other strategies

Cons

- Manufacturers recommend limiting the percentage supplied to less than 20 percent of the hood's exhaust



Face Discharge

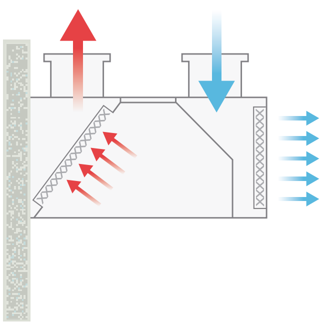
In common use in many fast food and full preparation kitchens

Pros

- Found to be effective in containing cooking fumes

Cons

- Care necessary to ensure as close as possible to horizontal discharge is achieved



Perforated Supply

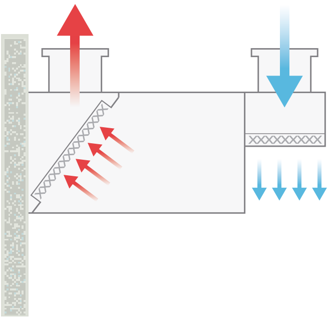
Similar to Face discharge

Pros

- Found to be effective in containing cooking fumes

Cons

- Recommended that only perforated plate ceiling diffusers area used to avoid generating air currents that influence extract



Ventilated Ceiling

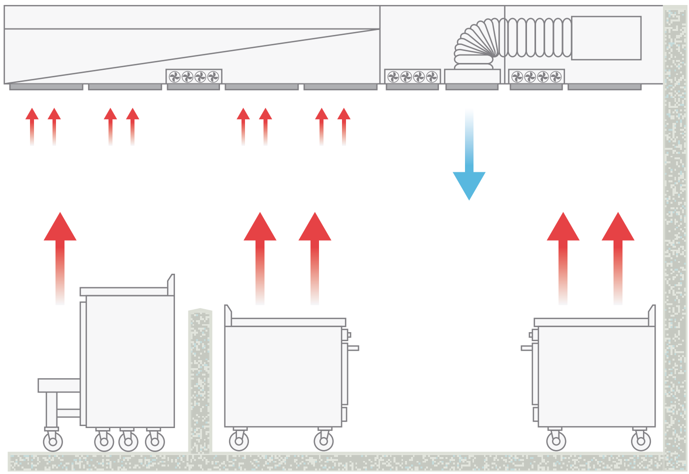
Good alternative kitchen exhaust canopy system

Pros

- Good aesthetics
- Possibility to change kitchen layout

Cons

- Plenum – risk of contamination
- Condensation risk



Ceiling Diffuser

Diffusers should not be located in close proximity to the canopy

Pros

- Provides good air distribution within the kitchen space and can improve the working environment

Cons

- Can adversely affect performance of kitchen exhaust if not designed correctly

8.0 Restaurant & Kitchen Design Guide

8.3 Low Energy Design Considerations

Location of cooking appliances and equipment
By grouping appliances according to heat and fume production, it is possible to reduce ventilation rate and the extract canopy size. Canopies can be split in sections via dividing plates and where a particular item of equipment requires a particularly high extract rate this can be dedicated to the specific section of the canopy. Where practical, place heavy-duty appliances such as char-broilers in the centre of a hood section, rather than at the end.

8.3.1 Canopy Style

The adopted geometry and style of the extract canopy influences the resultant extract volume requirements, and therefore has an impact on energy consumption.

Wall-mounted canopies hoods function effectively with a lower exhaust flow rate than the single-island hoods. Island canopy hoods are more sensitive to replacement air source. Low level canopies are often the most energy efficient as they require lower air flow rates for the same effectiveness typically 80% of the exhaust rate of a wall mounted canopy.

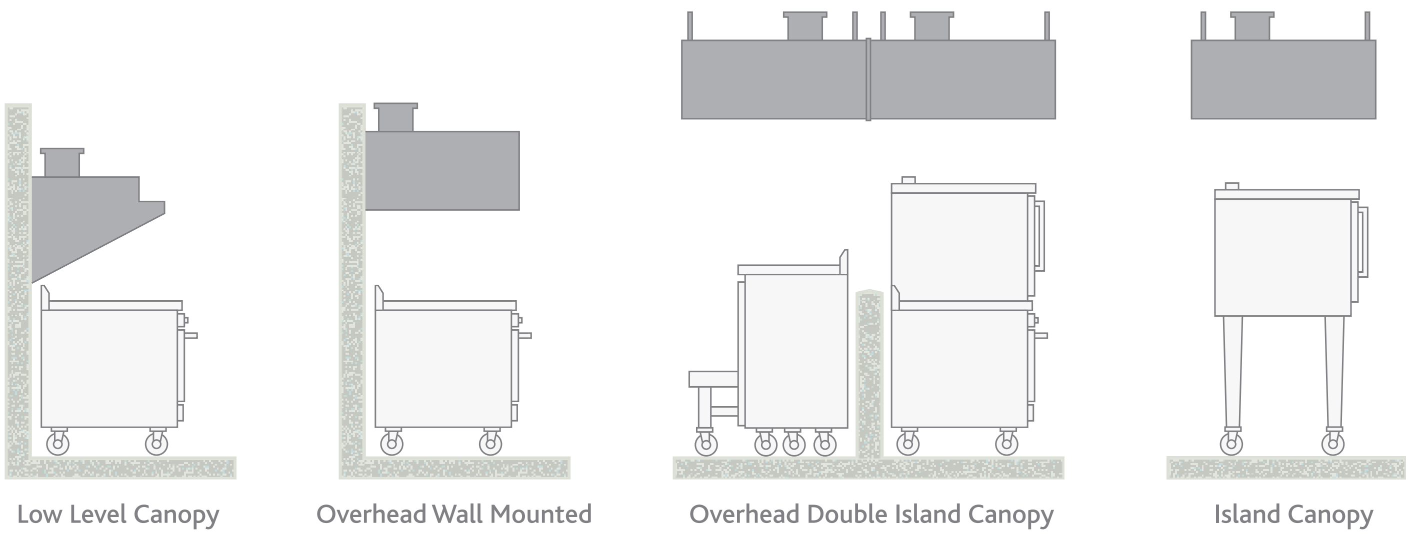
8.3.2 Canopy Side Panels and Overhang

Side (or end) panels permit a reduced exhaust rate in most cases, as they direct the replacement airflow to the front of the equipment.

They are a relatively inexpensive way to improve capture and containment and reduce the total exhaust rate. It should also be noted that one of the greatest benefits of end panels is to mitigate the negative effect of cross drafts and partial side panels can provide almost the same benefit as full panels.

Another benefit of side panels is that they mitigate the negative effect that cross drafts have on the extract canopy's performance. Additionally, partial side panels can provide almost the same benefit as full panels.

Fig.28 Typical Canopy Arrangemants



8.3.3 Variable Speed Fans

In the United States of America a recent advance in kitchen extract system has resulted in the increasing adoption of variable air volume (VAV) extract systems serving kitchen canopies. Compared to standard constant volume extract systems, this demand-based extract fan runs at an appropriate speed depending on output signals received from sensors within the canopy. In some instances appliances can be idle for much of the day. While the fans are not running at peak design flow rates continuously, operational energy savings are realised as a result of the corresponding reduced power input.

By adding variable frequency drives to the kitchen canopy extract fan and the replacement air supply fan, which modulate the fan's speed in proportion to the sensor and controller outputs. The sensors and control output arrangement options can be as follows:

Option 1 Ventilation modulates in accordance with gas supply or energy input to the cooking appliances. In this instance sensors would be integrated within the gas or power distribution to the appliance to monitor consumption.

Option 2 Ventilation modulates in accordance with fume or heat output from the cooking appliances. In this instance an optical sensor and heat detector would be integrated within the kitchen extract canopy to monitor the degree of appliance use.

Option 3 Ventilation modulates as a result of manual operation. In this instance the Chef or catering assistant directly control the extract ventilation rate when an appliance is operated using a controller on the canopy.

In each of the above options the controllers act to control the kitchen canopy extract and replacement supply air fans, which modulates the fan speeds up or down, accordingly. However, the fan must be arranged to provide a minimum level of ventilation to avoid grease particles in the rising air cooling and condensing back to the surface instead of being extracted.

Fan power is not the only area that savings are achieved; a reduced volume of exhaust air results in a reduced replacement air supply volume. Correspondingly, there is also a reduction in energy as a consequence of reduced heating or cooling demand.

The challenges related to such systems include:

- Ensuring the replacement balance is maintained
- Ensuring that minimum canopy extract rate provide adequate ventilation
- Providing a means of user override

8.3.4 Example

Based on actual kitchen layouts, an assessment has been carried out to illustrate the potential for optimisation and energy savings. The following assessments have been considered:

1. Commonly used approach to kitchen design.
2. Design options for reducing the extract and replacement air airflow rates without compromising capture and containment using variable air volume.
3. Considering alternative appliance arrangements to reduce the resultant extract volume.

8.0 Restaurant & Kitchen Design Guide (Base Case)

Example 1: A Small Restaurant Unit 250m² – Commonly adopted approach

8.4.1 This example considers a branded restaurant within the main shopping area. The unit is developed over a single floor, comprising:

- The main consumer space, with seating for approximately 60 people
- Customer and staff toilets
- Catering kitchen

8.4.2 Common Practice Design Approach

The base case considers the following scenario:

- Cooking appliances comprise a mixture of gas and electric items, which are located against a wall with a wall mounted canopy located directly above
- The canopy length is 4.05 metres, which includes an additional 250mm overhang
- Extract fan size 2.2kW (providing 1.62m^3/s)
- Fan operation is constant volume with manual operation
- Length of ductwork to discharge is 60metres

8.4.3 Common Practice Design Commentary

The base case considers a generic range of cooking appliances 0.75m deep, located against a wall, served by a 4.05m length overhead wall mounted canopy with open sides. The means of calculating the extract ventilation arrangement follows the methodology defined within HVCA Specification for Kitchen Ventilation Systems (DW/172 - 2005).

The method of interlocking the mechanical ventilation with the gas supply to ensure the ventilation system is switched on before the gas appliances are known as - Fan Electrical Current Proving.

Fig.29 Kitchen Appliance Details

Appliances	Appliance Areas m^2	Appliances Convection Coefficients	m^3/s	Extract Ventilation Rate (Including margin)
2 No. Deep Fat Fryers	1.13	0.45	0.504	–
Griddle	0.56	0.40	0.224	–
Dripping Tray For Fryer	0.3	0.35	0.105	–
Convection Oven	0.68	0.30	0.204	–
Canopy Factor	4.05	1.25	–	–
TOTAL			1.3	1.62m^3/s

- Base Model - Cook line arrangement

8.0 Restaurant & Kitchen Design Guide

Example 2: A Small Restaurant Unit 250m^2 – Energy efficient alternative using Variable Air Volume Extract

8.5.1 Design Approach

A variable exhaust system will automatically adjust the exhaust volume to match the amount of heat and fumes rising from the cooking appliances. Modulating the exhaust to match the rate of cooking reduces the exhaust and replacement supply air that must be heated or cooled.

The below modifications have been made to the Base Case to illustrate the potential benefit of integrating a variable air volume (VAV) kitchen extract system:

- Fan size 2.2kW (providing maximum extract 1.62m^3/s)
- Variable volume fan operation using variable frequency drives
- The inclusion of a system controller together with control sensors –types include:

1. Semi-Automatic *TruFlow* ™
   The controller measures the exhaust duct temperature to vary the amount of exhaust from the hood. As the duct temperature increases the exhaust volume modulates to the maximum value. If the exhaust volume does not increase fast enough to provide adequate ventilation an override is manually activated to drive the exhaust to the maximum value.
2. Automatic *Melink Intelli-hood* ™
   A duct temperature sensor provides an input signal to vary the amount of extract from the canopy. As the duct temperature increases, the volume increases to a maximum value. In addition optical sensors, located within the canopy, detect smoke and are also able to modulate the extract rate. An override push button is also provided, which increases the extract to the maximum value.

An assumed profile illustrating possible cooking activity within the kitchen area has been used and is shown opposite.

Fig.30 Variable Volume Fan use of Fan Capacity throughout the day

The graph illustrates the actual proportion of fan speed modulating as the cooking activity increases or decreases. It should be noted that the Base Case system will operate at a constant speed.

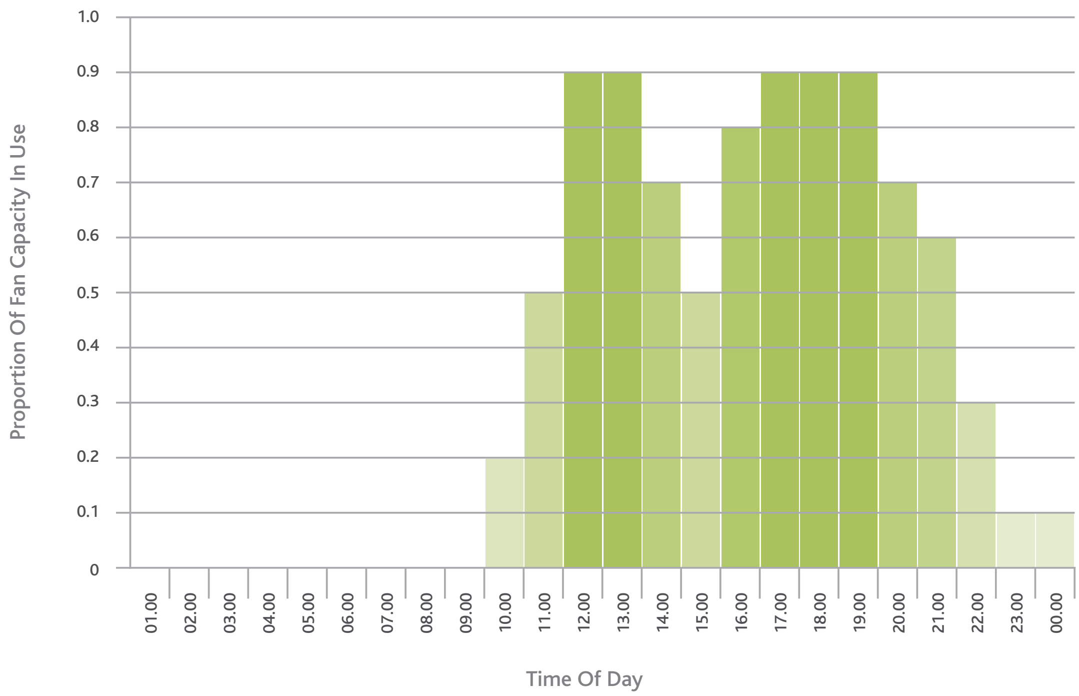


Fig.31 System Comparisons

The table below illustrates the energy consumption, together with capital and running costs. A possible fan system energy reduction of 60% is predicted in this instance.

	Common Practice Base Case System	Energy Efficient VAV Extract and Replacement System
Ductwork Cost	£32,720	£32,720
Fan & Controls Cost	£8,940	£17,800
Fan Annual Energy Consumption	17,500 kWh	7,200 kWh
Fan Annual Energy Cost [1]	£1,400	£576
Fan Annual Carbon Emission [2]	7.4 tCO_2	3.0 tCO_2

1 Energy cost based on 8p/kWh

2 Carbon dioxide emission for electrical energy based on 0.422kgCO_2/kWh

In addition to the estimated fan energy savings, are further potential savings in the order of 12% resulting from the reduced replacement air heating requirements.

8.0 Restaurant & Kitchen Design Guide

Example 3: A Small Restaurant Unit 250m^2 – Effect of optimising the location of equipment

8.6.1 Design Approach
The below modifications have been made to the Base Case to illustrate the potential benefit of optimising the location of cooking appliances:

- Cooking equipment uses gas and electric appliances, which are located against a wall with a wall mounted canopy directly over the appliances
- The workbench or tray has been relocated (coordination with the Chef or catering staff required) to one end of the cook-line, such that it is partially under the canopy
- The relocation of tray, allows a reduction in the canopy length from 4.05 to 3.65metres, which includes the additional 250mm overhang

The modification is illustrated within the below diagram.

8.6.2 System Comparisons
The above illustration indicates that by carefully considering the position of appliances with high heat coefficient rates beneath the canopy and relocating items no power source requirements at the ends, it is possible to reduce the required extract flow rate and correspondingly the canopy size without affecting performance.

The resultant arrangement has a 400mm reduction in canopy length, resulting in a potential 11% reduction in extract ventilation requirement of 1.44m^3/s (from 1.62).

As such a reduced fan size is possible – 1.5kW (from 2.2kW).

The results presented illustrate the annual operation of the extract fan only.

Fig.32 Base Model – Revised System Arrangement

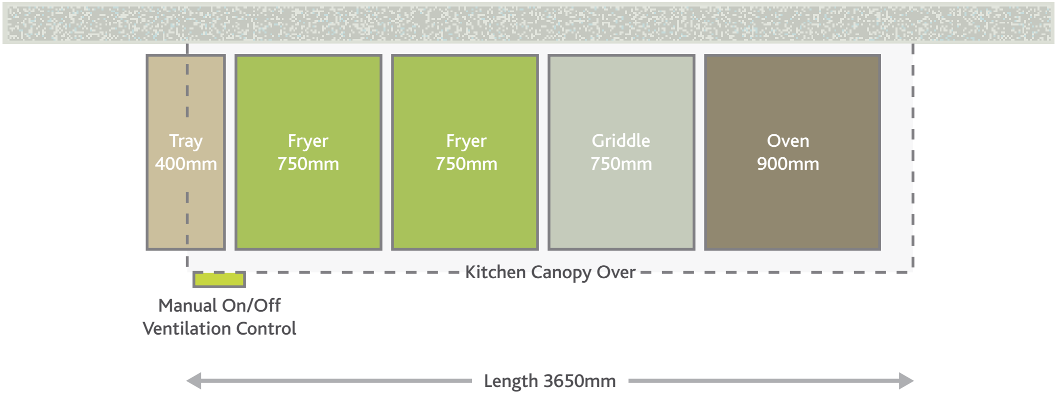


Fig.33 System Comparisons

	Base Case Extract Canopy	Reduced Size Canopy
Fan Annual Energy Consumption	9,400kWh	6,400kWh
Fan Annual Energy Cost	£752	£516
Fan Annual Carbon Emission	4.0 tCO_2	2.7 tCO_2

1 Energy cost based on 8p/kWh
2 Carbon dioxide emission for electrical energy based on 0.422kgCO_2/kWh

8.0 Restaurant & Kitchen Design Guide

"By properly designing exhaust ventilation systems for new restaurants, significant operational savings, energy efficiency, and environmental improvements can be achieved."

Appendices

1. No and Low Cost Energy Reduction Checklist

2. Summary of Regulatory Framework

Appendix 1. No and Low Cost Energy Reduction Checklist

The No and Low Cost energy reduction list has been compiled to provide simple guidance, which summarises options and strategies that can to help to reduce operational energy consumption and save money.

9.1 General

- The most energy-efficient lights and appliances are those that are not turned on. Make it policy to: "Turn it off when not in use".

9.2 Lighting

- Zone light switches so they can be used selectively. Label or colour-code light switches to ensure lights are on only when and where required.
- Ensure that cleaning staff use lighting wisely. Switching off 50% of the lighting should provide sufficient illumination for staff safe movement between work areas.
- Clean during daylight hours to take advantage of available borrowed or natural light.
- Keep background lights low so displays will seem brighter without being overly bright.
- Clearly define a lighting 'shut-off' procedure for closing and make an on-duty staff person responsible.
- Switch energy-intensive display lights off when the store closes. Add a "Last Person Out " switch.
- Keep lights off in service areas – including storage rooms, employee lounges and walk-in refrigerators – when closed or unoccupied. Turning lights off even for a few minutes at a time will save energy over the long run.
- Relocate hidden and inconveniently placed light switches, if possible. People are more likely to turn lights off when switches are easy to find.
- Make sure lighting controllers (time clocks and photocells) are well maintained and properly set.
- Check to ensure exterior lighting is off during the day.
- Use task lighting whenever possible. Carefully focus directional and spot lighting to minimize the amount of spill light.
- Reduce lighting during daylight and early-morning hours.
- Clean lamps regularly. Dirty lamps and fixtures can reduce effective light output by as much as 50%.

9.3 HVAC

- Provide company sweatshirts for cleaning and after-hours staff so temperatures can be lowered during cooler seasons.
- Do not heat or cool storage areas that are rarely occupied.
- Turn off ventilation when it is not required, such as during non trading or while facilities are closed.
- Ensure timer switches and thermostats are set to meet only minimum heating, ventilating and cooling loads – when and where needed.
- Ensure that all grilles and diffusers – including return-air vents are unobstructed by items such as boxes, curtains and displays. Blocking airflow reduces the efficiency of HVAC systems and increases energy costs.
- Avoid placing a lot of televisions, computers, lamps and other similar products near thermostats. The heat from these and other appliances or equipment may affect thermostat readings and lead to increased energy consumption for cooling.
- Cover and lock thermostats in common areas.
- Remove obstructions that restrict the free flow of air through heating and cooling units. Make sure air supply or return grilles are not blocked by furniture, books or magazines, which waste energy.
- If pipe insulation is removed or damaged after maintenance, ensure it is replaced promptly. Where regular maintenance access is required consider removable insulation.
- Make sure a qualified technician regularly maintains your HVAC equipment.
- Locate sitting office equipment to work with cooling zones to avoid excessive loads.

9.4 Office Equipment

- Shut down office equipment, such as photocopiers and computer monitors, when not in use.
- Procure low energy equipment, ideally with auto power-down modes.

9.5 Water

- Encourage cleaners to fully close all taps and to report dripping taps promptly. Use Signs above sinks and tap outlets.
- A toilet that runs between flushes can waste 750 litres per day. Encourage staff to report leaks promptly.
- Place awareness stickers in every wash/toilet area to remind customers and staff of the environmental benefits of wise water use.
- Set back hot-water tanks to 60°C, and ensure that insulation is applied to hot-water supply pipework and tanks.
- Drain and flush hot-water heater tanks twice a year or more often if water quality is exceptionally hard.
- Install waterless urinals which can have very short pay back periods.

Appendix 2. Summary of Regulatory Framework

10.1 Building Regulations 2010
The current building regulations look to reduce CO_2 emissions by 25% compared to 2006 levels, with a further 25% in 2013.

10.2 Energy Performance Certificates (EPC)
All new buildings, or premises about to be sold or let must have a valid EPC. The EPC can only be produced by an accredited assessor and is valid for ten years. It rates premises on a scale of A to G, similar to the energy efficiency labels familiar from white goods, and is an assessment of the predicted CO_2 emissions associated with the base-build and fit-out. It only looks at regulated energy, i.e. those energy uses covered within the Building Regulations.

10.3 Display Energy Certificates (DEC)
A DEC looks very much like an EPC but is based on 12 months of actual energy usage and must be renewed every year. It measures all of the energy used within the premises, not just the element covered with Building Regulations. At present DECs are only required by legislation for "public access" premises - ie schools, national and local government offices etc. However, it is anticipated that their use may soon be extended to offices and retail units.

10.4 Carbon Reduction Commitment Energy Efficiency Scheme (CRCEES)
The CRCEES is a carbon emissions trading scheme and is effective in the UK from April 2011. Any organisation, at its parent level, that uses over 6000 MWh of electricity in a year through half-hourly metering will be covered by the scheme. This means that national retail chains are likely to be included. The landlord of a shopping centre or retail park may well be covered by the CRCEES and be required to reduce emissions and trade permits in the carbon market. This may mean that individual retailers, even small independent traders, may well be captured through their occupation in these centres. It is in everyone's interest for landlord and occupier to work together to reduce energy consumption.