Cubic Apple
Unit 2, Abeles Way
Holly Lane Industrial Estate
Atherstone
Warwickshire
CV9 2QX

Report Supplement

Air Conditioning Inspection
For Report Example - Client

Prepared for

J Bloggs

Report Example
Report Example,
Report Example

Report Example, Client

Key Findings

Report Example - Client

Top 3 recommendations based on potential annual savings

Type	No.	Recommendation	Systems	Annual Saving *
Efficiency Improvements	1	When considering replacements for the systems on site, ensure that any new equipment is correctly sized for the area and a...	All Systems	£17,881.93
Efficiency Improvements	2	When budget permits, the client should consider replacing the inefficient systems with modern high efficiency inverter sys...	All Systems	£17,881.93
Efficiency Improvements	7	Consider the savings that could be made by installing PIR movement sensors, linked to the terminal units within infrequent...	All Systems	£5,364.58

* Assumes 0.12p per kWh and operational times as detailed in Table 2 of the report

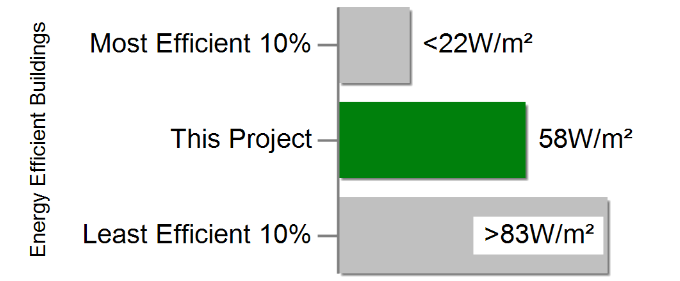
Building Performance

Total building Conditioned Area = **2135m²**

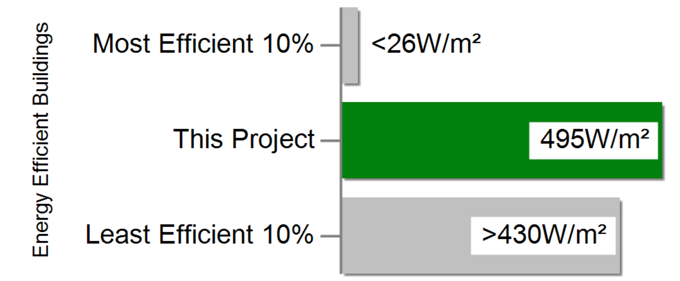
Installed Cooling Capacity = **456.9kW**

Comfort Cooling Conditioned Area = **2114m²**
Comfort Cooling Electrical Input = **122.1kW**

Process Cooling Conditioned Area = **21m²**
Process Cooling Electrical Input = **10.4kW**



Comfort Cooling Energy Input



Process Cooling Energy Input

The above figures are based on the average estimated energy consumption across 4000 inspected buildings carried out using the ACE Wizard Software since 2012. The figures do not include the kW consumption from installed chilled water pumps, chilled water fan coil units, mechanical ventilation systems, remote condenser fans, cooling tower fans or system redundancy. This figure should be used as a guide only and may not reflect the accurate W/m² of the inspected facility.

Estimated total Operational Cost = **£35,763.86 per annum** *
Total estimated kWhs per week = **5731.4kWhs** *
Total Building Refrigerant Charge = **135.0Kg**
Total System GWP (Global Warming Potential) Equivalent to **248 Tonnes CO2**

Building Average System Energy Rating

Air Conditioning Systems

EER 2.0 = G

Air Cooled Chillers

EER 3.6 = A

Water Cooled Chillers

N/A

Remote Condenser Chillers

N/A

Company Name	Report Example
Address	Report Example, Report Example

Name of Inspector	Deepak Thind
Inspector Number	STER500227
Accreditation Scheme	Sterling Accreditation
Inspection Date	04/10/2016
Report Expiry Date	03/10/2021

Inspection Company	Cubic Apple
Address	Unit 23 Abeles Way Holly Lane Industrial Estate Atherstone Warwickshire CV9 3AD

Important Notice

The following tables have been supplied as an addition to the mandatory air conditioning inspection report. These tables do not in any way form part of the official report and as such will not be lodged with the official report. They have been provided solely to supplement the report with the intention of enabling the client to have greater understanding of their HVAC plant and it’s energy consumption in an easy to read manner, whilst also providing sound general advice on some of the more frequently observed energy saving recommendations. It is hoped that the client finds this section extremely useful as they are provided over and above the legislative requirements.

Where information has not been provided estimates of installed cooling capacity and system operating data have been made using rules of thumb only. No guarantee as to the accuracy of the data or of the recommendations is made.

The inspection and subsequent report is provided to comply solely with the requirements of the EPBD. The inspection procedure has been conducted following guidance from CIBSE TM44 and is a visual observation inspection only. No detailed measurements have been carried out during the inspection process unless indicated otherwise.

Whilst reasonable steps have been taken to ensure that the information contained within this report is correct, you should be aware that it may be incomplete, inaccurate or may have become out of date. Accordingly, no warranties or representations of any kind as to the content of this report or its accuracy and, to the maximum extent permitted by law, the inspection company accept no liability whatsoever for the same including without limit, for direct, indirect or consequential loss, business interruption, loss of profits, production, contracts, good will or anticipated savings. Any person making use of this report does so at their own risk.

Recommendations...

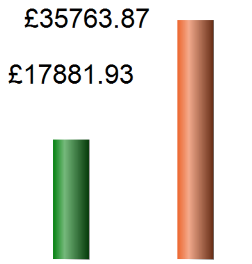
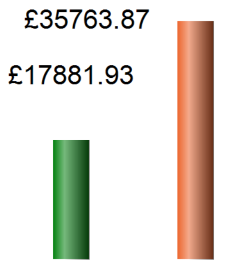
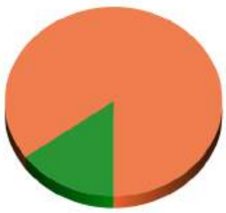
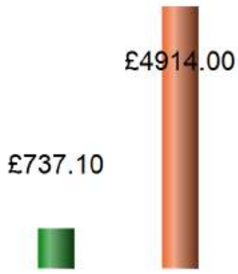
A summary of the key recommendations are made below with the estimated impact on operational costs.

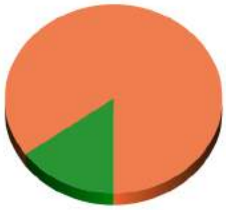
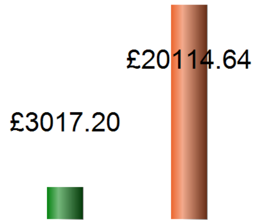
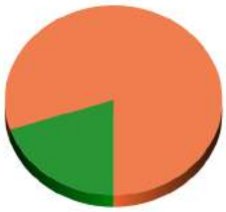
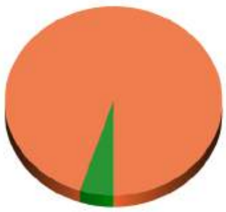
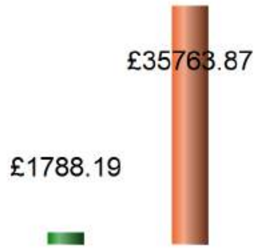
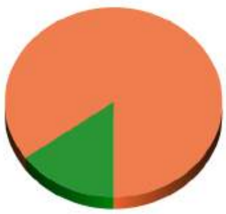
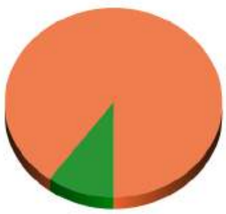
The consumption figures are provided as a guide only and no equipment has been metered by the inspector. To correctly analyse actual consumption data the client should sub-meter and monitor the individual items of plant.

Using manufacturer data, the total operational costs for all the systems on this site has been estimated to be **£35,763.86 per annum**. This figure is not definitive as it is affected by many conditions such as maintenance issues and temperature set points. It is therefore the case, that while certain recommendations such as the upgrading of inefficient systems will decrease this figure. Many of the recommendations will not result in a reduction from this figure but will prevent an increase in the annual operational costs over and above this figure. It is also the case that the estimated projected impact costs are applicable to the individual recommendation only and are not accumulative.

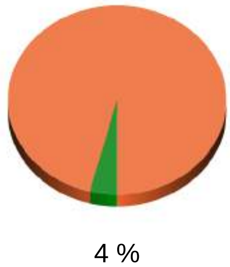
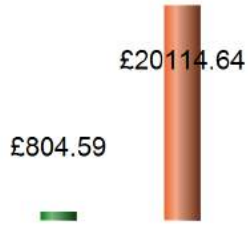
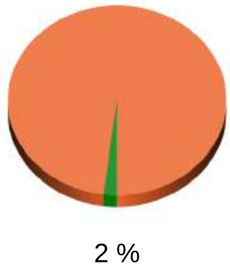
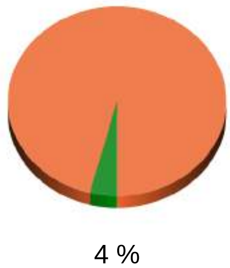
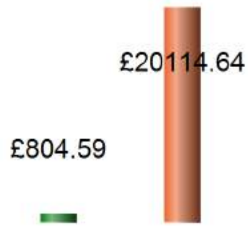
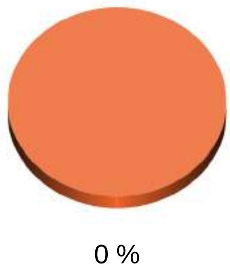
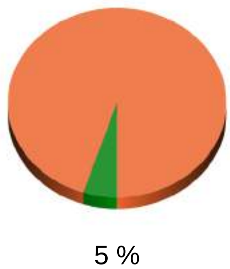
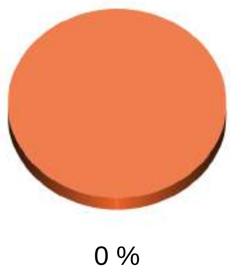
All calculations have been based on an average of 0.12p per kWh and assumes that systems are left to be operational for 52 weeks per annum during occupancy hours only and are not manually isolated during this time. It should be noted that energy calculations have been made using systems operating in cooling mode, this figure is usually marginally but not significantly, different when heat pump systems operate in heating mode.

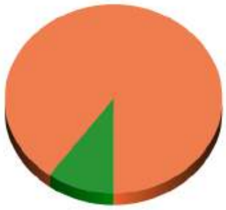
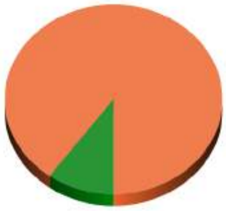
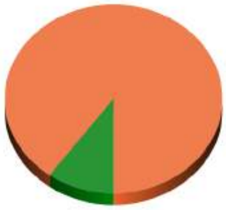
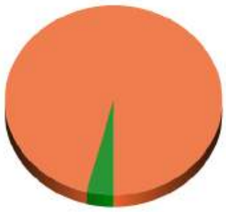
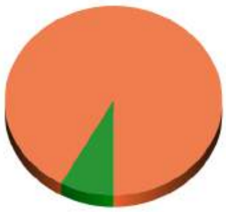
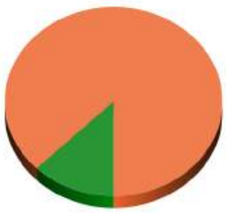
A more detailed explanation of the operating parameters and calculations used to estimate the consumption costs of the equipment can be found in section 3.

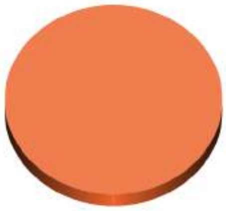
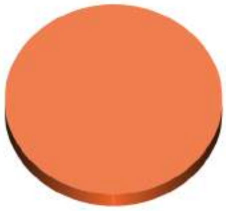
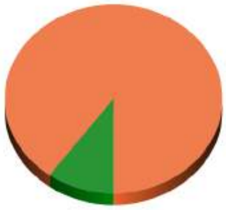
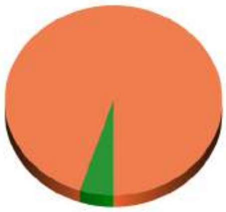
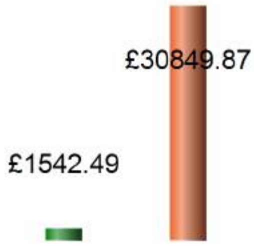
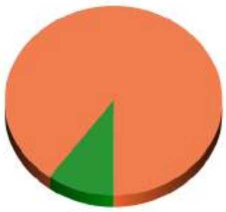
Action	Efficiency Improvements	Estimated Impact on Operation (%)	Applicable Systems	Potential Impact on Costs (per annum)
01	When considering replacements for the systems on site, ensure that any new equipment is correctly sized for the area and activities that it serves.	 50 %	All Systems	
02	When budget permits, the client should consider replacing the inefficient systems with modern high efficiency inverter systems.	 50 %	All Systems	
03	Consider retrofitting air blast coolers to enable the chillers to provide free cooling and increase chiller EER.	 15 %	AC14	

Action	Efficiency Improvements	Estimated Impact on Operation (%)	Applicable Systems	Potential Impact on Costs (per annum)
04	To optimise air flow ensure all AHU filters are high efficiency (Low energy) "A" rated filters.	 15 %	All AHU DX System Systems	
05	Consider the savings that could be made by upgrading the current belt driven motors within the AHUs to direct drive speed controlled EC motors.	 20 %	All AHUs	£0.00 £0.00
06	Consider sub-metering the individual items of HVAC plant on site and then record the energy consumption figures to enable areas of excessive consumption to be identified.	 5 %	All Systems	
07	Consider the savings that could be made by installing PIR movement sensors, linked to the terminal units within infrequently used areas, so as to automate the operation of the air conditioning systems.	 15 %	All Systems	
08	Consider the savings that could be made by installing window sensors linked to the air conditioning terminal units so as to prevent the systems from operating when windows have been opened.	 10 %	All Areas	

Action	System Maintenance	Estimated Impact on Operation (%)	Applicable Systems	Potential Impact on Costs (per annum)
01	The filters on the terminal unit should be inspected and cleaned by the refrigeration contractor at the earliest opportunity to ensure the most efficient operation of the system.	 8 %	All Systems	

Action	System Maintenance	Estimated Impact on Operation (%)	Applicable Systems	Potential Impact on Costs (per annum)
02	The coils on the external unit should be inspected and cleaned by the refrigeration contractor at the earliest opportunity to ensure the most efficient operation of the systems.		All AHU DX System Systems	
03	All refrigerant pipe work should be inspected by the refrigeration contractor at the earliest opportunity and any damaged areas of insulation repaired or replaced.		All Systems	
04	The finned heat exchanger matrix on the external / internal units should be inspected by the refrigeration contractor and any damaged areas repaired.		All AHU DX System Systems	
05	The build-up of dirt/mould observed on the terminal unit air grilles and supply duct should be cleaned at the earliest opportunity		All Systems	
06	The coils on the AHU should be cleaned to ensure the efficient operation of the system.		All AHUs	£0.00 £0.00
07	The cooling systems at this site appear to have received a good level of planned maintenance with no cause for concern.		N/A	£0.00

Action	Controls Action	Estimated Impact on Operation (%)	Applicable Systems	Potential Impact on Costs (per annum)
01	It is recommended that a study is completed on the occupancy profile of the building and it should be ensured that system time schedules match the occupancy hours of the building in all areas.	 10 %	All Areas	 £3084.99 £30849.87
02	Clocks on the system controller have not been seasonally adjusted and were found to be incorrect by 1 hour. This should be rectified to prevent the system operating when the area is vacant.	 10 %	All Systems	 £3576.39 £35763.87
03	It should be ensured that the current system time schedules are adjusted to reflect any holiday periods identified.	 10 %	All Systems	 £3576.39 £35763.87
04	Consider raising the chilled water flow set point to 10°C so as to reduce energy consumption.	 4 %	All Air Cooled Chiller Systems	 £196.56 £4914.00
05	Consider increasing the server room set point to, if possible, 27°C. This may be done in small increments to ensure equipment stability.	 8 %	Process Cooling	 £610.53 £7631.62
06	Consider the savings that could be made by implementing an AHU free cooling regime at this site.	 13 %	All AHUs	£0.00 £0.00

Action	Management Action	Estimated Impact on Operation (%)	Applicable Systems	Potential Impact on Costs (per annum)
01	Ensure a copy of the F-Gas Log Book is held on site & kept up to date.	 0 %	N/A	£0.00
02	The supplied asset list is not up to date and will require improving and updating as soon as possible	 0 %	N/A	£0.00
03	Consider placing notices alongside the local system controllers to advise occupants on the method of control for efficient operation of the AC system.	 10 %	All Areas	
04	Consider replacing the existing lighting within the building with energy efficient, low temperature lighting.	 5 %	All Areas	
05	Consider methods that will reduce the high level of solar heat gains to the building.	 10 %	All Areas	

Key Recommendations

Executive Summary

On 4 January 2003 the European Parliament and the Council of the European Union published Directive 2002/91/EC on the Energy Performance of Buildings (EPBD). This requires Member States to bring into force 'the necessary laws, regulations and administrative provisions to comply with the Directive'. Article 9 requires Member States to introduce measures to establish a regular inspection of air conditioning systems.

In England and Wales the Energy Performance of Buildings (Certificates and Inspections) (England and Wales) Regulations 2007 implement Articles 7-9 of the Directive. They require inspection of all air conditioning systems with rated outputs over 12kW at intervals not greater than 5 years.
The Inspection and Report were undertaken in accordance with CIBSE's methodology, Inspection of Air Conditioning Systems TM44: 2012 Edition by an inspector accredited to the National Occupational Standard and accredited by Sterling Certification.

The deadline for the first air conditioning assessment to be completed of all existing systems over 250 kW total cooling capacity was 4th January 2009.

The deadline for the first air conditioning assessment to be completed of all existing systems over 12 kW total cooling capacity was 4th January 2011.

New air conditioning systems over 12 kW which were installed after January 2008 must be inspected within 5 years of being put into service.

The total cooling capacity of a buildings air conditioning system is calculated by adding up the capacity of all the individual systems in that building.

Why are inspections required of the air-conditioning?

Having your air-conditioning system inspected by an Energy Assessor is designed to improve efficiency and reduce the electricity consumption, operating costs and carbon emissions for your system. Energy inspections will highlight improvements to the operation of your existing systems or opportunities to replace older, less energy efficient systems or oversized systems with new energy efficient systems.

As the replacement of refrigerant is restricted in older systems (as established under other legislation), there is an additional incentive to improve or replace older systems with more modern energy efficient units. Building owners and managers who control air-conditioning systems have statutory obligations and duties of care in the operation and maintenance of air-conditioning systems.

The energy assessment inspection discussed in this report is in addition to the normal activities associated with the ownership and operation of air-conditioning systems. Inspection, maintenance and cleaning programmes maintain the ability of the system to provide healthy and comfortable environments for building occupants, limiting the escape of refrigerant gases and ensuring the safety of equipment. The practices and procedures needed to achieve these aims should be applied more frequently than the assessment for energy efficiency.

What does the inspection cover?

The inspection visually examines a sample of refrigeration and air movement equipment, and their controls. Site notes, photographs, room measurements and temperature readings are taken during the inspection. It also examines any documentation that helps to understand the systems, or indicates the extent to which the systems have been maintained.
The energy assessor also estimates whether the system is suitably sized for the cooling loads in the treated spaces, and to provide advice on ways in which the performance of the system might be improved.

Building owners and managers should not expect the air conditioning energy assessment to identify hazards or unsafe aspects of the installation, operation or maintenance of systems that should be identified and addressed by other arrangements, nor should they expect the energy assessor to fix any problem identified as part of the inspection.

Building Description
University of ... - ... Campus is located on ... Lane, ..., ...
... is where sports and exercise, performing arts, events management and hotel and resort management subjects are studied.
The building is constructed via traditional steel frame, flat roof and double glazed windows.
Building Occupancy hours vary depending on term timetables and public use. Building occupancy on average is between 09:00 to 18:00 Monday to Friday.

CIBSE TM46 Energy Benchmarks gives a very good guide on the energy usage for different types of buildings and how to adjust your building usage for occupancy and other non-standards to provide a guide on what this buildings energy usage should be.

System Type/Details:
The building is cooled by one air cooled chiller, multiple DX condensing units supplying cooling via AHU's across campus and multiple single/multi split units serving various rooms within the ... campus. Areas covered range from lecture theatre, learning centre library, sports science IT suite, server rooms and classrooms. The cooling plants are located on the roof and to the rear of the building. The terminal units used within the building are air grilles, ceiling cassettes and wall mounted units. Majority of large equipment (AHU & chillers/DX units) are centrally controlled via BMS and the remaining rooms are via hard wired controllers.

The total installed cooling capacity is approximately 457kW.

Equipment Inspected:
For the purpose of the report samples have been taken in accordance with CIBSE TM44. Samples taken from areas demonstrate the age, condition and method of control. The Report is based on a visual inspection only. No equipment or plant was removed or stripped down. Cooling requirements have been calculated in accordance with CIBSE Guides and therefore should not be treated as an in depth heat load calculation.

Equipment inspected:
One external Airedale UCC125DQ air cooled chiller serving lecture theatre.
Two external Airedale DX condensing units serving sports science IT Suite & learning centre.
Two external Daikin condensers serving comms room & sports science FF.
One external Mitsubishi condenser serving sports science kitchen.
Four Barkell AHU's.
Two air grilles, one floor mounted unit, two ceiling cassettes & one wall mounted unit.
One centralised BMS system, two individual hard wired controllers.

An asset list was available at the time of the inspection, other essential system documentation including floor plans, schematics, cooling capacities and system method of control weren't available, for the purpose of the report documentation was prepared on site.

Inspection Findings:
The Air Conditioning units for the site are in good condition and observed to be maintained well.
Sub metering of the refrigerant plant should be installed for better monitoring which could lead to greater energy efficiency on site.

A number of opportunities are outlined within the report that should be considered to maximise efficiency. While there is no mandatory requirement to carry out any recommendations, acting upon the advice within the report may lead to a reduction in energy consumption and operating costs.

1 Tables & Calculations

1.1 External Plant Asset Register

System	Unit Location	Area Served	Manufacturer /Model	System Type	Refrigerant		*Rated Output	*Age	General Condition
					Type	*Charge (kg) (GWP Equivalent CO2 Tonnes)	(kW)		
AC14	Rear of Building	Learning Centre Theatre	Airedale UCC125DQ	Air Cooled Chiller	R407C	60.0 (106.440)	136.5	2006	Good
AC1	Rear of Building	Sports Science IT Suite	Airedale CUS5-IEM/01	AHU DX System	R407C	10.0 (17.740)	40.0	2006	Good
AC1 001	Rear of Building	Sports Science IT Suite	Airedale CUS5-IEM/01	AHU DX System	R407C	10.0 (17.740)	131.4	2006	Good
AC10	Rear of Building	Biomechanics Lab	Mitsubishi PUHZ-ZRP140VKA	Single Split	R410A	5.0 (10.440)	13.6	2013	Good
AC2	Rear of Building	Learning Centre	Airedale CUS15D	AHU DX System	R407C	18.0 (31.932)	41.8	2006	Good
AC3	Rear of Building	Sports Centre Fitness Suite	Carrier 38UQZ011K9DRD	AHU DX System	R407C	5.0 (8.870)	17.6	2006	Good
** AC4	Rear of Building	LRC Comms Room	Daikin RYP71L7W1	Single Split	R407C	2.8 (4.9672)	7.1	2004	Reasonable
** AC4 001	Rear of Building	LRC Comms Room	Daikin RYP71L7W1	Single Split	R407C	2.8 (4.9672)	7.1	2005	Reasonable
AC5	Rear of Building	Sports Science Kitchen	Mitsubishi PUHZ-P100VHA4	Single Split	R410A	3.0 (6.264)	10.0	2015	Good
AC6	Roof	Sports Science GF	Daikin RZQ140B8W1B	Single Split	R410A	4.3 (8.9784)	14.0	2006	Good
AC7	Roof	Sports Science FF	Daikin RQ100B8W1B	Single Split	R410A	3.7 (7.7256)	10.0	2006	Good
** AC8	Roof	Growth Hub Server Room	Daikin RR71B8V3B	Single Split	R410A	2.7 (5.6376)	7.1	2006	Good
** AC8 001	Roof	Growth Hub Server Room	Daikin RR71B8V3B	Single Split	R410A	2.7 (5.6376)	7.1	2006	Good
AC9	Rear of Building	Bio & Strength Conditioning	Mitsubishi PUHZ-ZRP140VKA	Single Split	R410A	5.0 (10.440)	13.6	2013	Good
Total Comfort Cooling:						**124.0**	**428.5**		
Total Process Cooling:						**11.0**	**28.4**		

Table 1 – Asset Register

**Systems AC4,AC4 001,AC8 and AC8 001 are for process/equipment applications and are not installed to provide comfort cooling.

* Where exact manufacturers data was not available, expected values have been based on similar system data.

1.1.1 Air Handling Units / Supply & Extract Fans

System	Unit Location	Area Served	Manufacturer /Model	Air Volume (m3/s)	Supply Motor Rating (kW)	Extract Motor Rating (kW)	VSD
AC11	Roof	Sports Centre Fitness Suite	Barkell Unknown	0.00	0.00	0.00	Yes
AC13	Rear of Building	Learning Centre	Barkell Unknown	0.00	0.00	0.00	Yes
AC12	Rear of Building	Learning Centre Theatre	Barkell Unknown	0.00	0.00	0.00	Yes
AC13 001	Rear of Building	Sports Science IT Suite	Barkell Unknown	0.00	0.00	0.00	Yes
			Totals:	**0.00**	**0.00**	**0.00**	

Table 1A – AHU Equipment List

1.2 Equipment Energy Usage

System	Manufacturer /Model	Time Zone	Period of Operation*		Electrical Costs Per kWh	kWhs Per Week **	Operation Costs	
			Hours Per Week	Weeks Per Year			Weekly (£)	Annual (£)
AC14	Airedale UCC125DQ	Mechanical Ventilation	50.0	52	£0.120	787.5	£94.50	£4,914.00
AC1	Airedale CUS5-IEM/01	Mechanical Ventilation	50.0	52	£0.120	1337.7	£160.52	£8,347.25
AC1 001	Airedale CUS5-IEM/01	Mechanical Ventilation	50.0	52	£0.120	1337.7	£160.52	£8,347.25
AC10	Mitsubishi PUHZ-ZRP140VKA	Comfort Cooling	50.0	52	£0.120	107.8	£12.94	£672.67
AC2	Airedale CUS15D	Mechanical Ventilation	50.0	52	£0.120	338.1	£40.57	£2,109.74
AC3	Carrier 38UQZ011K9DRD	Mechanical Ventilation	50.0	52	£0.120	210.0	£25.20	£1,310.40
AC4	Daikin RYP71L7W1	Process Cooling	168.0	52	£0.120	294.0	£35.28	£1,834.56
AC4 001	Daikin RYP71L7W1	Process Cooling	168.0	52	£0.120	294.0	£35.28	£1,834.56
AC5	Mitsubishi PUHZ-P100VHA4	Comfort Cooling	50.0	52	£0.120	76.0	£9.11	£473.93
AC6	Daikin RZQ140B8W1B	Comfort Cooling	50.0	52	£0.120	112.7	£13.52	£703.25
AC7	Daikin RQ100B8W1B	Comfort Cooling	50.0	52	£0.120	93.1	£11.17	£580.94
AC8	Daikin RR71B8V3B	Process Cooling	168.0	52	£0.120	317.5	£38.10	£1,981.32
AC8 001	Daikin RR71B8V3B	Process Cooling	168.0	52	£0.120	317.5	£38.10	£1,981.32
AC9	Mitsubishi PUHZ-ZRP140VKA	Comfort Cooling	50.0	52	£0.120	107.8	£12.94	£672.67
AC11	Barkell Unknown	Mechanical Ventilation	50.0	52	£0.120	No Data	No Data	No Data
AC12	Barkell Unknown	Mechanical Ventilation	50.0	52	£0.120	No Data	No Data	No Data
AC13	Barkell Unknown	Mechanical Ventilation	50.0	52	£0.120	No Data	No Data	No Data
AC13 001	Barkell Unknown	Mechanical Ventilation	50.0	52	£0.120	No Data	No Data	No Data

Comfort Cooling Cooling Costs:	497.4	£59.68	£3,103.46
Mechanical Ventilation Cooling Costs:	4011.0	£481.31	£25,028.64

Process Cooling Cooling Costs:	1223.0	£146.76	£7,631.76
Totals:	**5731.4**	**£687.75**	**£35,763.86**

Table 2 – Estimated System Operating Costs

* The calculated figures assume that systems operate for 70% of occupancy time to achieve internal set temperatures (Excluding water chillers and mechanical ventilation systems).

** DX/Split systems with part load capabilities have had a 30% reduction to input power applied to reflect modulation.

*** Mechanical Ventilation figures have been based on fans operating for 100% of occupancy times.

**** Chillers - An "Average Seasonal Energy Input" figure based on ESEER (European Seasonal Efficiency Ratios) has been estimated to calculate chiller operating costs.

A more detailed explanation of the operating parameters and calculations used to estimate the consumption costs of the equipment can be found in section 3.

Manufacturer /Model	Number of Systems	Manufacturers Rated Input *(kW)	Total Rated Input (kW)	Energy Efficiency Ratio	Energy Label Class	Inverters Y/N
Airedale CUS15D	1	13.8	13.8	3.0	B	Yes
Airedale CUS5-IEM/01	1	54.6	54.6	0.7	G	Yes
Airedale CUS5-IEM/01	1	54.6	54.6	2.4	E	Yes
Airedale UCC125DQ	1	38.2	38.2	3.6	A	Yes
Carrier 38UQZ011K9DRD	1	6.0	6.0	2.9	C	No
Daikin RQ100B8W1B	1	3.8	3.8	2.6	D	Yes
Daikin RR71B8V3B	2	2.7	5.4	2.6	D	No
Daikin RYP71L7W1	2	2.5	5.0	2.8	C	No
Daikin RZQ140B8W1B	1	4.6	4.6	3.0	B	Yes
Mitsubishi PUHZ-P100VHA4	1	3.1	3.1	3.2	A	Yes
Mitsubishi PUHZ-ZRP140VKA	2	4.4	8.8	3.1	B	Yes
Total:	**14**		**197.9**			

Table 3 – Plant Energy Usage

* Where exact manufacturers data was not available, expected values have been based on similar system data.

When systems are operating at full power the total kW input of the air conditioning refrigeration systems at this building is **197.9kW**. As systems capable of part load operation rarely operate at full power a more realistic input figure to reflect modulation of the installed systems is **132.5kW**, this figure will be used as the base for the energy calculations throughout this report.

The Energy Efficiency Ratio (EER) is calculated on the amount of energy input required to produce the stated cooling kW output of each unit. The higher the EER number, the more efficient the unit is deemed to be. It should be noted that the EER is not constant and will vary depending on external and internal temperatures, air flow restrictions including filter and coil conditions and many other factors.

With ever increasing pressure to reduce energy consumption the refrigeration manufacturing sector has made some very positive advances in improving the overall system Energy Efficiency Ratio (EER), reducing the energy input required to produce a similar level of cooling. With inverter technology enabling systems to operate at part load it is not unusual to find systems with an EER of up to and over 5. The table below has been included to demonstrate energy label classification compared to EER.

Eurovent, the European Committee of Air Handling and Refrigeration Equipment Manufacturers has established its own classification for systems operating at full load EER. The following table shows the Eurovent clasifications. However For systems which operate at part load a more accurate approach is to calculate the ESEER (European Seasonal Energy Efficiency Ratio). The ESEER should be established by contacting your equipment manufacturer.

Energy Rating Label	Air Cooled Chiller (EER)	Water Cooled Chiller(EER)	Remote Condenser (EER)	VRV/F Split & Multi-Split(EER)
A	≥ 3.1	≥ 5.05	≥ 3.55	> 3.2
B	2.9 - 3.1	4.65 -5.05	3.4 -3.55	3.0 - 3.2
C	2.7 - 2.9	4.25 -4.65	3.25 - 3.4	2.8 - 3.0
D	2.5 - 2.7	3.85 - 4.25	3.1 - 3.25	2.6 - 2.8
E	2.3 - 2.5	3.45 - 3.85	2.95 -3.1	2.4 - 2.6
F	2.1 - 2.3	3.05 -3.45	2.8 -2.95	2.2 - 2.4
G	< 2.1	< 3.05	< 2.81	< 2.2

Table 4 – Eurovent Full Load Chiller and Air Conditioning Energy Classification (Cooling Mode)

1.3 Building Occupancy

Time Zone	Weekly Occupancy/ Trading Hours	Weekly Plant Set Hours	Total Plant Energy Consumption (kW)*	Expected Weekly Consumption (kWh)	Surplus Weekly Operational Hours	Surplus Weekly Energy Consumption (kWh)
Comfort Cooling	50.0	168.0	14.21	497.4	118.0	1173.7
Process Cooling	168.0	168.0	10.40	1223.0	0.0	0.0
Mechanical Ventilation	50.0	62.5	107.85	4011.0	12.5	1002.8

Table 5 - Surplus Time Schedule Costs

* Systems with part load capabilities have had a reduction applied to reflect modulation.

** A more detailed explanation of the operating parameters and calculations used to estimate the consumption costs of the equipment can be found in section 3.

The table above compares the occupancy hours with the plant time schedules which were observed at the controllers during the inspection. If plant timers have not been set up or are not in line with occupancy hours then this should be rectified. Significant fiscal and energy savings can often be realized by this simple operation.

During the HarmonAC field trials it was concluded that setting timers correctly was the single biggest energy conservation opportunity (ECO) that could be made by companies. It was also found that in more than 10% of trials systems were found to be operational outside of occupancy hours when manual isolation was common practice.

It is also strongly advised that all clocks on controllers are checked to ensure they display the correct time and date and they are seasonally adjusted. By neglecting to change clocks from summer to winter time will result in systems operating when areas are unoccupied. Based on an 8 hour working day this is an additional 12.5% of unrequired operation per day.

The table represents the estimated weekly energy consumption for the Comfort Cooling, Process Cooling and Mechanical Ventilation air conditioning systems at this site.

The final column shows the potential additional weekly wastage when usual occupancy hours are compared to plant timer settings and although may not reflect actual usage, highlights the importance of ensuring that where possible all timers are set to reflect occupancy hours. By implementing correct time schedules this site could potentially save **1979.6 kWh** per week which equates to **£12352.84 per annum**

1.4 Size Comparison

The following tables shows that the average comfort cooling load density across all comfort conditioned areas of this building is **203 W/m2** and the average energy consumption to operate this equipment is **58 W/m2**.

Total Comfort Cooled Area * (m2)	Total Comfort Cooling Capacity (kW)	Cooling Load Density (W/m2)	Total Cooling Electrical Input (kW)	Comfort Cooling Energy Input (W/m2)
2114	428.5	203	122.1	58

Table 6A – Total Site Comfort Cooling Density and Energy Input Density

Total Process Cooled Area * (m2)	Total Process Cooling Capacity (kW)	Cooling Load Density (W/m2)	Total Cooling Electrical Input (kW)	Process Cooling Energy Input (W/m2)
21	28.4	1352	10.4	495

Table 6B – Total Site Process Cooling Density and Energy Input Density

*Where detailed measurements were not supplied, conditioned area has been based on basic onsite measurements.

During the inspection the kW output of a number of systems was compared to the areas they operate in, the following tables shows the inspection results:

Area Served	System	Conditioned Floor Area (m2)*	Number of Occupants	Occupant Density (m2 per person)	Cooling Load Density (W/m2)**	Required Cooling Capacity (kW)	Actual Cooling Load (kW)	Variance (%)	Actual Cooling Load Density W/m2	Comment	Partial Loading Capability
Learning Centre	AC13, AC2	890	100	8.90	110	97.9	41.8	-57%	47	Undersized	Yes
Sports Centre Fitness Suite	AC11, AC3	340	50	6.80	300	102.0	17.6	-83%	52	Undersized	No
LRC Comms Room	AC4, AC4 001	12	0	12.00	400	4.8	14.2	196%	1183	Oversized	No
Sports Science Kitchen	AC5	24	5	4.80	110	2.6	10.0	285%	417	Oversized	Yes
Sports Science GF	AC6	170	20	8.50	300	51.0	14.0	-73%	82	Undersized	Yes
Sports Science FF	AC7	170	20	8.50	300	51.0	10.0	-80%	59	Undersized	Yes
Growth Hub Server Room	AC8, AC8 001	9	0	9.00	400	3.6	14.2	294%	1578	Oversized	No
Bio & Strength Conditionin g	AC9	180	40	4.50	110	19.8	13.6	-31%	76	Undersized	Yes
Sports Science IT Suite	AC1, AC1 001, AC13 001	250	40	6.25	110	27.5	171.4	523%	686	Oversized	Yes

Table 7 – Calculated Room/System Cooling Loads

*This is an estimate based upon measurements taken on site.
**Estimated sizing requirement has been based on the BSRIA rule of thumb for cooling load densities (W/m^2) (See Table Below) However adjustments may have been made where high occupant densities or excessive heat loads / heat gains are thought to be factors.

It should be noted that estimated cooling loads are based on a 'rule of thumb' and may not reflect the actual cooling load. It is normally acceptable for a margin of error of ±20% as per the latest guidelines from CIBSE.

Systems which are installed with a partial loading capability will modulate power in accordance with demand, this will help to negate oversizing in areas where they are installed.

As can be seen from the above table, that systems AC3, AC4, AC4 001, AC8 and AC8 001 are not fitted with inverters, this will result in full power operation when cooling/heating is required.

Equipment	BSRIA's Rule of Thumb Sizing (Wm^2)
Offices General	100 - 160
Offices Internal	70
Retail Establishments	140
Banks	160
Hotels	150
Restaurants	200
Residential Buildings	70

Table 8 – 5th Edition BSRIA's Rule of Thumb – Cooling Load Densities

1.5 Maintenance Regime

The information below highlights that the installed equipment is being maintained as regularly as recommended good practice guidelines.

Equipment	Expected Frequency (Months)	Actual Frequency (Months)	Maintenance Standard
Internal Filters	6	6	2
Internal Units Other	6	6	1
External Units Coils	6	6	2
External Units	6	6	1
External Pipe Insulation	6	6	2

Table 9 –Current Maintenance Regime

The general maintenance standard of the inspected equipment has been graded 1 to 4, where 1 is very good and 4 is very poor. As the maintenance of the systems is generally of a very good standard it should not be necessary to increase the frequency of the PPM.

By ensuring that filters are free of dust can greatly increase the efficiency of air conditioning systems. During the HarmonAC field trials it was found that when it was deemed visually necessary to clean a condenser by brushing or blowing out, the efficiency was reduced by an average of 3.9%. It was also recorded that dusty filters which produced a 7.5% loss in air flow resulted in a 21.5% decrease in efficiency.

It is not unusual to find external pipe insulation weathered and in a deteriorated state. Heat gains and heat losses due to poor insulation will affect the temperature of the refrigerant and therefore affect evaporation temperatures. It is always recommended that pipe insulation is regularly checked and repaired / replaced when necessary.

1.6 F-Gas/ODS Requirements and Refrigerant Data

As from 01/01/2015 The F-gas regulations have changed, to ensure you fully understand your legal leak testing compliance obligations please contact your air conditioning maintenance company.

Refrigerant leakage is costly in both energy and environmental terms. A 15% loss of refrigerant can, in some instances, increase power consumption by 100%. Additionally, the commonly used refrigerants have a much higher GWP (Global Warming Potential), most F-gases used in UK air conditioning are between 1,000 and 3,500 times more powerful then CO^2 in terms of their Global Warming Potential. The new F-Gas regulations are based on the GWP of a refrigerant multiplied by the weight of the refrigerant held within a system.

Table 10 below shows the total GWP all of the systems at this building. **Table 11** shows the number of systems which require mandatory leak testing at this site under the 2015 F-Gas regulations.

Refrigerant	GWP (kgCO2 GWP100a2)	Total Site Charge (kg)	Equivalent CO2 (Tonnes)	No Units
R407C	1,774	108.6	193	7
R410A	2,088	26.4	55	7
	Total:	**135.0**	**248**	**14**

Table 10 - Refrigerant Charge and Equivalent CO2

System GWP - Equivalent CO2 (tonnes)	Number of Units	Requirement Leak Inspection Frequency
GWP < 5 Tonnes	2	Not Required
GWP >= 5 Tonnes And < 50 Tonnes	11	Annual
GWP >= 50 Tonnes And < 500 Tonnes	1	6 Monthly
GWP >= 500 Tonnes	0	3 Monthly

Table 11 – F-Gas/ODS Legal Requirements

Under new F-Gas legislation 11 of the systems on this site requires an F-Gas log book and an annual leak test as the Global Warming Potential within the system is greater than the equivalent of 5 tonnes of CO2.

Under new F-Gas legislation 1 of the systems on this site requires an F-Gas log book and a 6 monthly leak test as the Global Warming Potential within the system is greater than the equivalent of 50 tonnes of CO2.

1.7 Air Handling Unit Sizing and Specific Fan Power

An examination of the installed fan capacities was carried out and has been tabulated below, and has been based on CIBSE recommended air flow rate of 10l/s. It can be seen the present system is providing enough fresh air for more than **0** people. Present occupancy levels are around **300** people.

AHU	Area Served	Air Flow (l/s)	Recommend l/s Per Person	Applicable Occupancy Level	Actual Occupancy Level *	Comment **	VSD
AC11	Sports Centre Fitness Suite	No Data	10	No Data	50	Undersized	Yes
AC12	Learning Centre Theatre	No Data	10	No Data	100	Undersized	Yes
AC13	Learning Centre	No Data	10	No Data	100	Undersized	Yes
AC13 001	Sports Science IT Suite	No Data	10	No Data	50	Undersized	Yes
			Total:	**0**	**300**		

Table 12 – Mechanical Ventilation Air flow Capacity

* Actual occupancy levels have been based on observations made during the inspection.

** A tolerance of +/-20% has been applied.

It can be seen from the above table, that AC11,AC12,AC13,AC13 001 are fitted with VSDs (Variable Speed Drives), these should reduce the air flow rates when necessary and ensure all motors are modulated down in accordance with demand negating the oversizing in these areas.

As the Air Flow rates for AC11,AC12,AC13,AC13 001 could not be established,they have been excluded from the total air flow rates calculation.

AHU	Air Flow (m3/s)	Motor Power Supply/Extract (kW)*		Specific Fan Power (SFP) (kW/m3/s)	Current Building Reg. SFP (kW/m3/s) Compliance Guide
AC11	0.0	0.0	0.0	No Data	2.20
AC12	0.0	0.0	0.0	No Data	2.20
AC13	0.0	0.0	0.0	No Data	2.20
AC13 001	0.0	0.0	0.0	No Data	2.20

Table 13 - AHU (Specific Fan Power) SFP

*The fan power has been de-rated to 70% of the installed motor power to obtain a realistic absorbed fan power.

The (SFP) Specific Fan Power shown above is the measurement used to assess the efficiency of the installed fans in an AHU compared to the power required to operate these fans. The current recommended maximum level for similar type AHUs is shown in the final column.

Building Type	New Buildings SFP (W/(l/s)	Existing Buildings SFP (W/(l/s)
Central mechanical ventilation (including heating and cooling)	1.8	2.2

Building Type	New Buildings SFP (W/(l/s)	Existing Buildings SFP (W/(l/s)
Central mechanical ventilation (heating only)	1.6	1.8
All other central systems	1.4	1.6
Zonal supply systems where the fan is remote from the zone	1.2	1.5
Zonal extract system where the fan is remote from the zone	0.6	0.6
Zonal supply and extract ventilation units such as ceiling void or roof units serving a single area with heating and heat recovery	2.0	2.0
Local supply and extract ventilation systems such as wall/roof units serving a single area with heating and heat recovery	1.8	1.8
Local supply and extract ventilation units such as window/wall/roof units serving a single area	0.4	0.5

Table 14 - Specific Fan Power (SFP) taken from Non-Domestic Building Compliance Guide 2010

2 Site Photographs

Figure 3 -

Figure 2 -

Figure 5 -

Figure 4 -

Figure 7 -

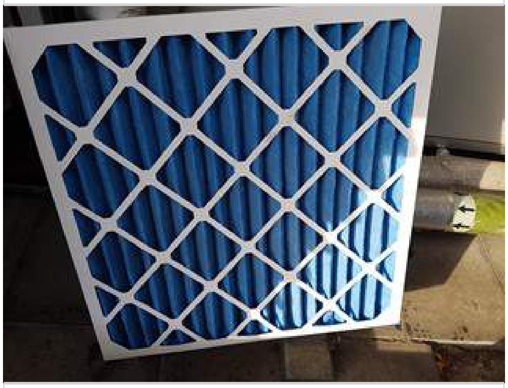


Figure 6 -

Figure 9 -

Figure 8 -

Figure 11 -

Figure 10 -

Figure 13 -

Figure 12 -

3 ACE WIZARD Energy Calculations

The calculations made within the ACE Wizard software are based on rules of thumb only and no equipment has been metered during the inspection.

Although every effort has been made to ensure that where possible, the calculations are in line with industry standards so as operational costs and savings can be realistically represented. It should be noted that the calculations are intended to be “ball park” figures only and are not intended to replace a detailed examination of actual operational costs. In all cases it is always strongly advised that metering of equipment is put in place so as building owners are aware of the costs to operate their systems.

Equipment consumption has been based on the manufacturer’s operating data, where this data is not available specifications from similar system types and sizes may have been used. Manufacturer’s data itself is based on systems operating at specified design parameters and include certain criteria such as benchmarked internal and external temperatures. No provision is made within the ACE Wizard for calculating the consumption of systems operating outside of the manufacturers specified design parameters. And no provision is made to reflect circumstances that would deviate from systems operating outside of design conditions such as the deterioration of components, fouling of coils and filters or loss of refrigerant (Unless stated). It is therefore the case that many systems, particularly older systems or systems in a poor state of repair may consume far more energy than has been stated and therefore greater savings than have been calculated may often be possible.

All Air conditioning units have been calculated as though they are operated for 52 weeks per year and are not manually isolated during the operational hours. This enables the costs for heating in the winter from heat pump systems as well as cooling in the summer months to be taken into account; it also means that process cooling systems such as server systems which require year round cooling can be calculated. If these figures are not reflective, ie the systems are used in summer only or they are manually isolated when rooms are vacant, then the client has the opportunity to make adjustments to this data and to tailor the usage of each system to help ascertain specific site costs. This facility is available on line at www.acewizard.co.uk and by logging in with the attributed user name and password.

Assuming an average seasonal temperature, air conditioning systems usually operate for approximately 70% of the time to achieve an internal space temperature of 22°C. This 70% reduction to the operational hours has been applied to all energy calculations within the reports, with the exception of chilled water systems. It has also not been applied to mechanical ventilations systems which have been calculated to operate for 100% of the set time.

It should also be noted that energy calculations for heat pump units which operate in heating mode have been made using input figures for cooling mode not the heating mode input figure. However these figures are not usually significantly different from each other and as such “ball park” figures are still represented.

Calculating Chillers & Chilled Water Circuits

Chiller Calculations	**AC14 Airedale UCC125D Q**
EER This figure is the full load efficiency ratio.	**3.6**
Base ESEER This is the base figure that has been used to calculate part load efficiency ratio.	**4.7**
ESEER Reduction (%) A percentage reduction applied to reflect ageing/fouling and wear and tear of components: (this can often reduce system efficiency by around 3% per annum).	**0**
Adjusted Base ESEER	**4.680**
Chiller Cooling Capacity (kW)	**136.5**
Average "Seasonal Cooling Duty" (kW) Based on the ESEER "Weighting Coefficients" detailed below	**73.710**
Seasonal Average kW Input (kW) (Seasonal Cooling Duty divided by Adjusted Base ESEER)	**15.750**
Sizing Adjustment (%) A percentage adjustment applied to reflect the level of under / over sizing of systems comparative to the area served. (See Section 1.4)	**0**
"Seasonal Average kW Input" (kW) This is the average hourly input figure which has been used for calculating the operating costs of this chiller.	**15.750**

Table 15 - Chiller Calculations Used At This Site

Eurovent, the European Committee of Air Handling and Refrigeration Equipment Manufacturers, has set its own formulae to calculate EERs (Energy Efficiency Ratio), making it easier to compare the performance of chillers manufactured by Eurovent accredited companies. Eurovent EER values are only valid at specified ambient and water conditions. In the case of air cooled packaged chillers, the unit EER must be given at 7/12ºC flow and return water conditions at 35ºC ambient. As with the EER value of air conditioning systems, the higher the EER value the more efficient the chiller and then classifications based on this follow an A to G approach, with A as the most efficient and G the most inefficient. Within Northern Europe the climate is such that if chillers are sized correctly then full power operation will only occur for a very limited period of the year, (approximately 3%). It is for this reason that the efficiency of a chiller when it operates at part load is more applicable than the full load efficiency. A method of calculating chiller efficiency based on part load operation has also been introduced by Eurovent. This is known as the ESEER (European Seasonal Efficiency Ratio). As with EER, the higher the ESEER value, the more efficient is the cooling system. The calculation equation is:

ESEER = A*EER100% + B*EER75% + C*EER50% + D*EER25%
Using the following weighting coefficients:
A = 0.03, B = 0.33, C = 0.41, D = 0.23 ESEER = 0.03A + 0.33B + 0.41C + 0.23D

The ACE Wizard software takes into account a number of parameters when calculating chiller operating costs. But is based around establishing an “Average Seasonal Input Value (kW)” for each chiller and multiplying this by the run hours / weekly operation hour. The “Average Seasonal Input Value (kW)” is calculated by using the Eurovent weighting coefficients as detailed above to firstly establish an “Average Required Seasonal Cooling Duty” (Cooling kW Output) of the chiller and then dividing this figure by expected part load ESEER figure. If the ESEER figure is not known then this is estimated based on similar system efficiency.

Chiller Load	Weighting Coefficients for part load Operation %	Air Temperature at Condenser Inlet (°C) (Air Cooled Chillers)	Water Temperature at Condenser Inlet (°C) (Water Cooled Chillers)
100%	0.03	35	30
75%	0.33	30	26
50%	0.41	25	22
25%	0.23	20	18

Table 16 - Eurovent ESEER Weighting Coefficients and Parameters

The above table of weighting coefficients is used by Eurovent to help gauge the efficiency of a chiller when part load input is taken into account (ESEER). These weighting coefficients are also used in the ACE Wizard software to help calculate an “Average Required Seasonal Cooling Duty” for each chiller. This is demonstrated in the example table below, where the output duty of a 300kW chiller is calculated at 100% load, 75% load, 50% load and 25% load is multiplied by the weighting coefficient to determine the chillers “Average Seasonal Cooling Duty” (kW).

Chiller Load	Chiller Output (kW)	Weighting Coefficients for part load Operation %	Seasonal Average Cooling Duty (kW)
100%	300	0.03	9.0
75%	225	0.33	74.25
50%	150	0.41	61.50
25%	75	0.23	17.25
Seasonal Average kW Cooling Duty= sum of above			162.0 kW

Table 17 - Calculating 'Seasonal Average kW Input'

From the above table it can be seen that a correctly sized 300kW chiller would be expected to produce 162.0kW of cooling duty as a seasonal average. If the ESEER of this chiller is expected to be 3.0 then the “Average Seasonal Input Value” (kW) would be 54kW.
However as chiller operational costs are inextricably linked to the size of the area they serve and whether or not it is correctly sized for that area. The ACE Wizard facilitates further adjustment to the “Seasonal Average Input Value (kW)”, if required, by a specified percentage to help reflect additional/reduced load when over/under sizing of a chiller is apparent. For example if a chiller is 30% undersized for the area it is serving then by increasing the “Seasonal Average Input Value (kW)” by 30% will reflect the extra work a chiller will have to do to achieve the required cooling level throughout a season.
In the case of the example above, if the chiller is considered to be 30% over sized this percentage could be applied to the “Seasonal Average Input Value (kW)” which would in turn raise this final figure from 54.0kW to 70.77kW, and this would be the “ball park” figure that the annual energy calculations could then be based upon.

Appendix A - Sensors, Controls & Metering

Most sensors can be incorporated into the existing building services and are easy to install as they generally utilise the existing wiring so there is no need for a specialist installer. In addition to this the sensors can usually be linked back to a BMS on site so as to provide the client with monitoring and logging capabilities; many sensor packages also offer the ability to link in and control other building services such as lighting and supply/extract fans.

With a return on investment expected within 6 to 12 months the cost to savings benefits provided by the correct implementation and control of multiple linked sensors can be substantial.

Movement Sensors

Movement sensors are particularly useful in areas of a building that are not in constant use, such as meeting rooms, gymnasiums and staff rooms, but can also be used in open plan offices where individually owned spaces are conditioned by specific units. Just ten 2.5kW (average) air-conditioning units running for 1 hour each per day whilst rooms are unoccupied results in 25 hours of wasted energy per day and approximately 13.6Kg of unnecessary carbon emissions. Therefore by installing and utilising movement sensors correctly a significant energy and fiscal saving can be realised in some cases.

Figure A-1 - PIR Movement Sensor

A particularly useful way to control the operation of the air conditioning systems within areas such as meeting rooms is by installing a standalone wall or ceiling mounted PIR movement sensor. Some sensors, such as the range provided by Johnson Controls, control the operation of the air conditioning system through the terminal units IR remote signal capability. The movement sensor can also be linked to any window/door sensors that may operate in the same area to prevent a system from operating when a window has been opened. Options are available on the sensor itself, through the use of DIP switches, to manually set the¬ hold off period from a few seconds up to 10 minutes or more. Some movement sensors even come fitted with a built in temperature sensor to provide a low temperature cut-off to prevent over cooling providing further energy savings.

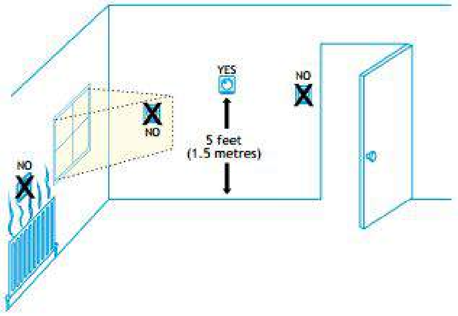
Figure A-2 - Temperature Sensor

Window, Door & Temperature Sensors

Window/door and temperature sensors can be installed as required to improve the level of control and the overall energy efficiency of an air conditioning system. As previously mentioned, by fitting window sensors within conditioned areas and linking them back to the air conditioning systems operating in these areas it is possible to prevent the systems from operating when a window has been opened as this uses a significant amount of energy needlessly.

Temperature sensors could be used to provide a more accurate room temperature reading for a VRV/VRF system or alternatively to link the operation of several split systems serving the same open plan area, such as a large open plan office. The use of one or more wall mounted sensors placed intelligently within a conditioned space could provide the terminal units with a more accurate space temperature and allow the systems to operate correctly without internal temperature sensors being affected by the unit location or adjacent heat sources such as computers or photocopiers.

A difference of just 1K in the temperature read at the terminal unit temperature sensor can result in up to 4% increased energy consumption and therefore ensuring that the temperature reading supplied to the system is an accurate reflection of the internal space temperature is paramount.



In addition to installing temperature sensors, the placement of these sensors is also of great importance as wrong placement can substantially affect the reading taken. The sensors should not be in direct sunlight, by a door or positioned above heat sources such as radiators or computer equipment. The sensors should be placed mid wall approximately 5 feet from the floor so as to provide the most accurate reading of the space temperature.

Figure A-3 - Temperature Sensor Positioning

Centralised Building Controllers

A centralised OEM controller could be the most effective way to consolidate the control, operation & monitoring capabilities of all the HVAC plant on site.

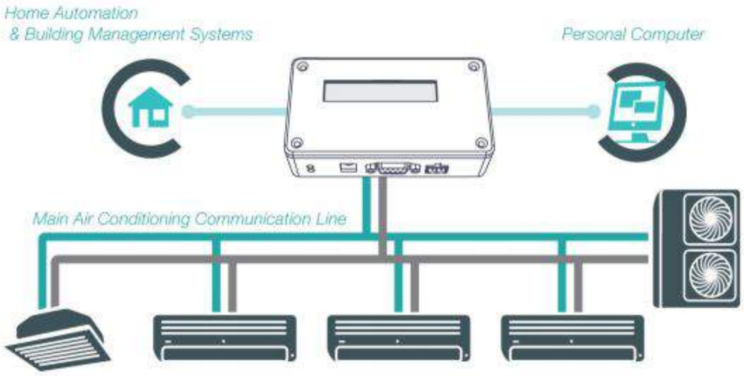


Figure A-4 - Centralised Controller Setup for Single Manufacturer

One controller setup, manufactured by Johnson Controls, for a larger HVAC system is to install a master controller interface that has the ability to be linked to nearly 30 individual input/output sensors and actuating devices as well as over 10 outstation controllers which could be linked to FCUs, AHUs etc. This master controller is then able to be linked back to the BMS on site to provide the user with a visual representation of operation, monitoring and logging and is also installed with a timer function to override all in built timers and automate the operation of the systems from a central schedule. The controller interface itself is usually installed with a web server, so the client can access logging & monitoring data from a remote location, as well as the ability to report out of range alarms and other logging details via SMS, phone, email or printer.

Other central controllers which are more specifically used for VRV/VRF and split systems are also available, such as the CoolMaster range from CoolAutomation.

This system offers a range of interface devices that are compatible with all of the major brands. A single interface is usable with a VRV/VRF system and can be linked directly into the main communication line between the cooling plant and the terminal units to allow for full control of the internal units and provide operational monitoring of the internal and external units.

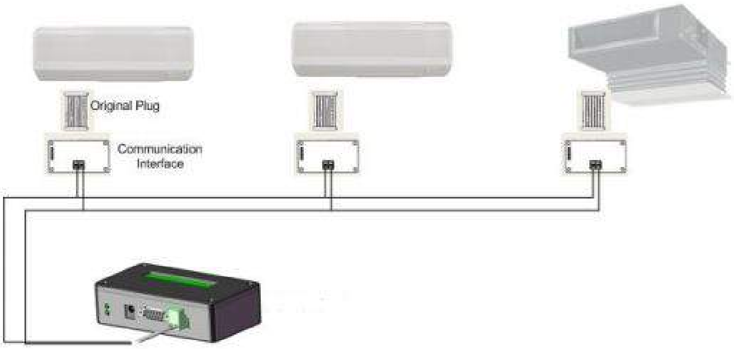


Figure A-5 - Centralised Controller Setup for Multiple Manufacturers

Alternatively, if the site consists of several different split systems with different manufacturers then individual communication interface devices can be installed to each of the systems and linked together for combined overall control of the systems.

Each of these types of system come with a simple RS232 interface connector for easy integration and once connected to the air conditioning system, they do not require any additional configuration. After connecting the wiring, supplying the power and defining addresses of the indoor units the system is ready to work.

Sub Metering

Metering the total energy used in a building is important, but it does not show how energy consumption is distributed across areas or applications such as:

- Multi Unit Sites
- Floor Levels in Multi Storey Buildings
- Departments Within Businesses
- By Tenant; Useful When Accurate Tenant Billing is Required

Figure A-6 - Smart Meter

Installing sub-metering to measure energy use in selected areas or by specific machinery will provide a considerably better understanding of where energy is used and where there is scope for savings to be made. Also, for new non-domestic buildings, sub-metering is laid out in Part L2 of The Building Regulations and requires at least 90% of each incoming energy source to be accounted for through sub-metering.

To improve energy management in buildings that are not complex i.e. a single HVAC system, quick and large wins can often be made by initially focussing on analysing the main utility meter readings. Sub-metering is particularly helpful for buildings with more complex building services systems and for investigating power load issues that cannot be resolved from the main meter readings. Using the data collected from sub-meters, individual weekly reports can be created highlighting consumption profiles, along with comparisons and trends.

Appendix B - New F–Gas Regulations 2015

The F-Gas regulation 842/2006 has been repealed and replaced with the new EU Regulation 517/2014 on fluorinated gases. This came into effect on 1st January 2015.

The reasoning behind the changes to the regulation is to promote a gradual reduction in F-Gases (gases which contain fluoride) from now until 2050 to help reduce the effects of global warming associated with these gases.

Most F-gases are between 1,000 and 20,000 times more powerful then CO^2 in terms of GWP (Global Warming Potential). Therefore the way GWP is calculated has been revised to reflect the equivalent tonnes of CO^2; changing the GWP of HFC's and HFC refrigerant blends.

Leak testing changes have been made to the limiting quantities which define the frequency of leak testing. The previous limits of 3kg, 30kg & 300kg have been replaced with a number relating to the equivalent tonnes of CO^2. The new labelling takes effect from 01/01/2015. Units with less than 3kg of refrigerant will be exempt until 01/01/2017. The equivalent tonnes of CO^2 must be displayed on the system label alongside the actual weight and type of refrigerant.

To calculate the equivalent tonnes of refrigerant the following simple equation is used;
Equivalent tonnes of CO^2 = Weight of refrigerant x Global Warming Potential / 1000

Leak testing Frequencies

Product and Equipment	**Minimum Frequency**
Systems with GWP < 5 tonnes CO2	Not Required
System with GWP = > 5 and < 50 tonnes CO2	12 Monthly
System with GWP = > 50 and < 500 tonnes CO2	6 Monthly
System with GWP = > 500 tonnes CO2	3 Monthly
If a system is fitted with refrigerant leak detection equipment it will reduce the frequency of mandatory leak testing (See chart below).	
Hermetic systems with GWP < 10 tonnes CO2	Not Required

The following table shows the new requirements for leak testing limits (kg) using the equivalent tonnes of CO2 compared to the old system of weights.

Previous Limits For Testing		**3.00kg**	**30.0kg**	**300kg**
HFC	**Global Warming Potential (GWP)**	**Weight (kg) equivalent to 5 tonnes CO2. (12 Monthly)**	**Weight (kg) equivalent to 50 tonnes CO2. (6 Monthly)**	**Weight (kg) equivalent to 500 tonnes CO2. (3 Monthly)**
R404A	3922	1.28kg	12.8kg	128kg
R422D	2729	1.73kg	17.3kg	173kg
R410A	2088	2.39kg	23.9kg	239kg
R407C	1774	2.82kg	28.2kg	282kg
R134a	1430	3.49kg	34.9kg	349kg
R32	675	7.41kg	74.1kg	741kg
R1234ze	7	714.30kg	7143.0kg	71430kg

New Legislation Labelling and Equipment Information

Record keeping (system log books) will be as per the previous regulation and manual records must be kept on site and up to date by the operator for a minimum of 5 years, if electronic versions are not available.
Log books must contain:

- The quantity and type of gas installed in each system
- Any quantities of gas added
- The quantity of gas recovered during servicing, maintenance and final disposal.
- The identity (including address and telephone number) of the company or personnel who performed the servicing or maintenance, as well as the dates and results of leakage checks and leakage detection system checks.

The Label on the unit (which must be visible and indelible) must include:

- A reference that the equipment contains or its function relies on HFC's
- The designation of the HFC concerned.

From 01/01/2017 all labels must included the weight and the equivalent tonnes of CO^2, or for uncharged units the weight and GWP with a clear space for the installer to add the final quantity.

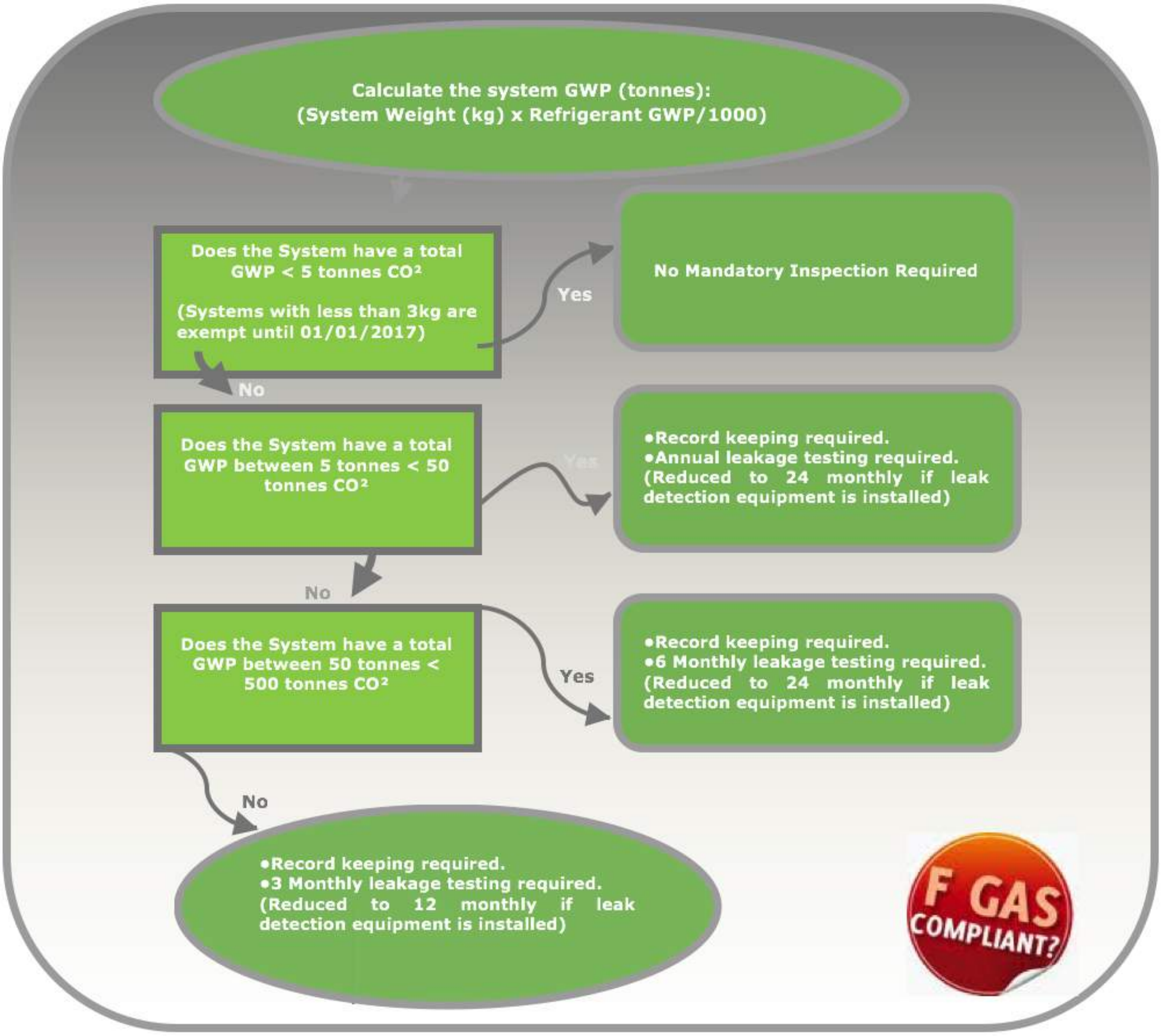


Figure B-1 - F-Gas Flow Chart

Appendix C - Reducing Solar Heat Gains

Excessive solar heat gain and solar glare can be a costly and an unwanted hindrance for building owners. In addition, local building regulations (Building Regulations Part L 2010) increasingly require designers to reduce heat gain with solar shading recommended as a preventative measure unless glass areas are minimised.

External shading devices are the most efficient thermally because they intercept the solar energy before it has entered the room and thus, even if energy is absorbed by them, it is not trapped behind the glass. They carry the disadvantage of having to be weatherproof and are more difficult to control from inside. Internal shading is usually much cheaper to install and is easy for users to control but is generally less efficient.

Solar Shading

Solar shading, such as retractable shutters, overhangs or fixed grids, is one of the most effective ways to control the internal conditions within a building and properly designed external solar shading can reduce heat gains through glazing by as much as 85%. In addition to this, solar shading can be used in conjunction with night time free cooling within a building to achieve comfort conditions without the need for mechanical cooling as well as reducing direct glare whilst allowing high levels of diffused natural light, giving a further potential energy saving by reducing artificial lighting needs.

Calculations based on the Bentley Hevacomp mechanical building designer software show that a typical office building can suffer 5-20% of total heat gain through glazing and therefore properly designed shading could reduce overall building running costs by 3-13%.

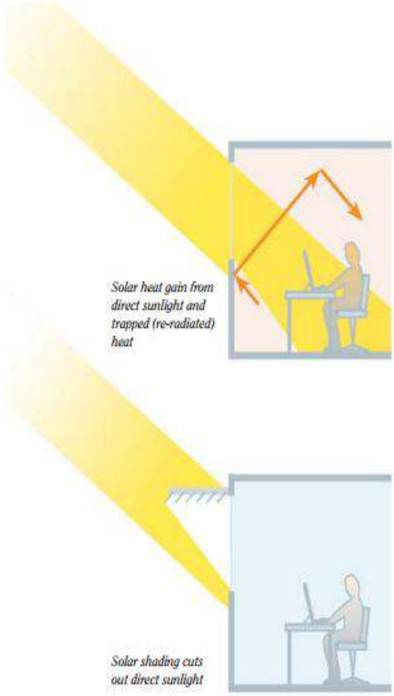


Figure C-1 - Effects of Solar Shading

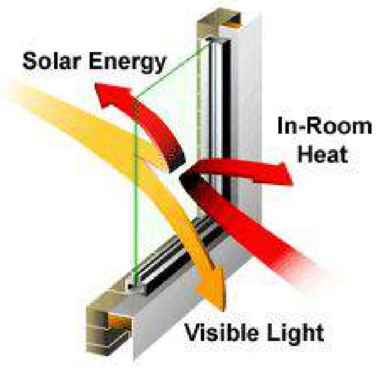
There are many types of external solar shading to be considered some of which are listed below:

- **Retractable – Shutters, Roller Blinds and Louvers**
  Retractable devices can adjust the total transmission of the glazed opening and diffuse reflection and at times of low sky brightness can be withdrawn from the aperture completely.

- **Fixed Redistribution Device – Overhangs and Light-Shelves**
  A fixed structure obscures part of the sky through which the sun passes and is selected due to the geometry of the device in relation to the facade and its orientation, allowing lower intensity and more diffused light into the room.

Window Film

The traditional type of solar film has been dark and heavily mirrored however; modern technology now allows for clear solar control window film to provide up to 58% solar energy rejection with visible light transmission as high as 70%. The lightest of these films is all but unnoticeable from inside or out, having a minimal visible light reflection of just 8%. These films are ideal for protecting display items in shop fronts, with UV rejection of over 99.9%.



Standard Window Film

U-value and emissivity values vary for standard window films, depending on the type of film, with emissivity values ranging from 0.70 to 0.81. Whilst providing excellent savings during cooling season, these window films reduce solar gains through windows all year-round, even when heat gain might be helpful i.e. during the winter. Therefore, in climates with prolonged heating seasons, such as the UK, these window films can increase the amount of heat needed from the building's HVAC system.

Figure C-2 - Effects of Solar Film

Reflective Window Film

High quality reflective solar control window film provides almost 80% solar energy rejection and is the most effective solar control film available. In addition to its solar reflective and glare reducing properties, the visual privacy provided by its mirrored appearance makes it an extremely popular material for commercial premises with windows adjacent to public areas.

Low-Emissivity (Low-E) Film

Low-E window film directs both solar and radiant heat back to its source providing a perfect balance of energy efficiency & thermal comfort whilst providing cost savings of over 10% in all year round building costs. Traditional low-e window film improves insulating performance of existing windows by 44%; higher-performance, newer low-e window film can improve insulating performance by as much as 92%.

Window Film Type	Standard Film	Reflective Film	Low-E Film
Total Solar Energy Rejected	49%	79%	75%
Visible Light Transmission	60%	15%	32%
Glare Reduction	32%	83%	64%
Shading Coefficient	0.59	0.24	0.28

Table C-1 - Window Film Comparison

Appendix D - Energy Efficient Lighting

Across the UK, lighting is responsible for up to 25% of commercial electricity use so it is vital to explore ways of reducing overall lighting costs. There is a 'triple-bottom line' benefit to upgrading to low-energy lighting:

- **Environmental Benefits** – Higher efficiency lighting consumes up to 80% less electricity and, therefore, less carbon pollution.

- **Operational Benefits** – Longer life bulbs provide reduced maintenance costs. Higher internal luminosity improves productivity and results in a better working environment.

- **Financial Benefits** - Inefficient lighting can make up the majority of onsite electricity costs whereas high efficiency lighting reduces energy consumption and provides a predictable return on investment, typically a payback of less than 1-2 years. In addition, newer lighting options generally produce less heat reducing internal heat gains and, in turn, operating costs for cooling solutions such as air conditioning.

The Hawthorne Effect

The Hawthorne Effect refers to a series of experiments carried out on workers from a factory called 'Hawthorne Works' where the initial purpose was to study the effects of lighting on worker productivity; researchers found that productivity almost always increased with a change in the level of illumination. In addition to this, low light and a lack of light has been linked with depression, so much so that light is actually used as a treatment for depression.

When considering a replacement programme to low energy lighting, comparisons should be made between the initial costs involved and potential energy savings as well as the level of luminosity provided and the life span of the lamp itself. There are several types of low energy lighting available each with their own benefits:

Compact Fluorescent Lighting (CFL)

Also known as energy saving light bulbs, CFLs are 4x more efficient and last up to 10x longer than everyday incandescent light bulbs. Although initially more expensive, the fiscal savings in the long run are substantial as CFLs use a 1/3 of the electricity than incandescent varieties whilst also providing a warm inviting light instead of the 'cool white' light provided by older fluorescents. Retro fitting CFLs is possible in nearly all situations as many of the fittings are the same as the current incandescent lamps.

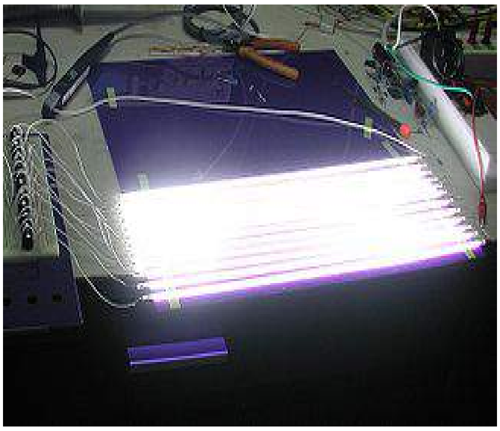


Figure D-1 - Cold Cathode Lighting

Light Emitting Diode (LED)

LED lamps are over 8x more efficient than the average incandescent light bulb and have an operational life of up to 50,000 hours, in comparison to an incandescent light bulb of up to 1,200 hours. For lights in very inaccessible places, using LEDs would eliminate the need for difficult bulb replacement for many years and in commercial premises there is a significant maintenance cost in replacing light bulbs, which can be virtually eliminated.

Energy Efficiency & Energy Costs	Incandescent Light Bulbs	Compact Fluorescents (CFLs)	Light Emitting Diodes (LEDs)
Life Span (Average)	1,200 hours	8,000 hours	50,000 hours
Electricity Used (W) (Equivalent to 60 Watt Bulb)	60 watts	13-15 watts	6 - 8 watts
Electricity Used (kW) (Equivalent to 30 Incandescent Bulbs per Year)	3285 KWh/yr.	767 KWh/yr.	329 KWh/yr.

Table D-1 - Lighting Energy Efficiency Comparison

Cold Cathode

Cold cathode lighting has an operational lamp life of at least 50,000 hours and does not deteriorate from repeated switching on & off like standard fluorescent tube lighting. As well as providing a high level of lumens per Watt, high frequency low-voltage cold cathode gives a 30% energy saving when compared to traditional systems and produces substantially less heat than standards fluorescent lighting reducing internal heat gains. The cold cathode lamps can also be retrofitted to existing F15-T8 fluorescent tubing reducing the capital expenditure involved in a replacement programme.

	Cold Cathode	Typical White LED
Lumens per Watt	105 to 124 lumens/watt	12 to 22 lumens/watt
Lumen Maintenance	< 0.2% loss per 1,000 hours	> 6% loss per 1,000 hours
Typical Lamp Life	50,000 to 100,000 or more hours	< 10,000 hours to 1/2 of original brightness
Color Uniformity	Consistent over tube length	Must be bin matched

Figure D-2 - Cold Cathode Vs LED

Appendix E - R22 Phase-Out & Equipment Replacement

R22 is a member of a class of compounds, Hydro Chlorofluorocarbons (HCFC), which have been linked to ozone depletion in the earth's upper atmosphere. As from 1st January 2010, the use of virgin R22 and other HCFCs in the repair and maintenance of air conditioning and other refrigeration equipment was banned. The regulations also outlaw the stockpiling of virgin R22 for use after the deadline so any R22 left unused at the end of 2009 should have been returned for destruction at the owner's expense.

A ban on the production of refrigerant R22 came into effect from the 1st January 2010. The refrigerant is still available in a reclaimed format until December 2014 however; as over 65% of the UK's systems are assumed to still be operating on R22, and as the demand has risen due to the recent phase out, prices are expected to rise to extreme levels, if they have not already.

Year	Effect of Ban
2000	Supply of CFCs(1) for servicing and maintenance. Restrictions also applied to the supply and use of halons, trichloroethane, carbon tetrachloride, hydrobromofluorocarbons and bromochloromethane.
2001	Use of CFCs for servicing and maintenance; also a ban on the installation of new large cooling equipment using HCFCs(2).
2002	New small cooling equipment using HCFCs banned. The deliberate release of HCFCs into the atmosphere was also banned.
2004	New recycling heat pumps using HCFCs banned.
2010	The use of virgin HCFCs banned; only recycled or reclaimed HCFCs now permitted.
2015	The use of recycled and reclaimed HCFCs to be banned.

Figure E-1 - R22 Phase-Out Schedule

The options available to owners of R22 air conditioning equipment are:

- Do Nothing!
- Continue to use recycled R22
- Replace the refrigerant with a 'drop in' alternative
- Replace your equipment

Do Nothing

Regulations do not prohibit the use of R22 equipment even after the December 2014 deadline however; depending on how crucial the system is to your business, the risk of failure is increasing as the years go by and even now spare parts are increasingly difficult to source.

Recycled R22

A recent study by the British Refrigeration Association identified that a volume equivalent to just 10% of the amount of virgin R22 currently being used in the UK is being returned for recycling making it up to 3 times the cost of virgin R22. Unless the situation improves radically, its poor availability and high cost means that a policy of relying on recycled R22 when the need arises is unlikely to be wise.

'Drop In' Alternative

R22 can be replaced with a few alternatives such as R417a and R422D however; this should only be considered as a short term fix since parts will be difficult to source and other issues can also relate to the energy performance of the system such as, the pressure rating of compressors, lubricant compatibility and potential conflicts with manufacturer warranties.

Replacement of Equipment

At first sight, this seems to be the most expensive solution however; there are a number of factors which make this alternative increasingly the option of choice for owners, operators and maintenance contractors alike. The first and main reason is that as any R22-based air conditioning system is at least 6 years old and likely, therefore, to be driven by obsolete fixed-speed compressor technology, its replacement with a modern, digital inverter-controlled system will bring significant immediate energy savings of up to 50%. The cost and time spent replacing out-dated equipment can be reduced in some cases by retaining existing pipe work and electrical supplies and a new system is also far less likely to suffer a breakdown and will commonly come with the added benefit of a manufacturer-backed 3 or 5 year warranty.

In addition, most new systems incorporate heat pump technology as standard adding the benefit of the summer air conditioning system providing high efficiency winter heating, further reducing energy costs.

Much of the new energy-efficient technology is also listed on the Enhanced Capital Allowance (ECA) Scheme allowing equipment owners to offset the entire cost of the project against its taxable profits in year the new system is installed.

The Enhanced Capital Allowance (ECA) Scheme was established to encourage UK business to invest in energy efficient equipment. The scheme provides 100% first year allowances for spending on equipment that meets published energy-saving criteria in the Energy Technology List (ETL), which currently features over 6,000 products. Through claiming an ECA, businesses can claim a reduction on their business taxable profit by the full cost of spending in the year the investment is made. This provides a helpful cash flow boost and a shortened payback period in addition to cost saving from reduced energy bills.

The Carbon Trust offers interest free Energy-Efficiency Loans to qualifying organisations with the potential to invest in energy-savings projects that replace or upgrade existing equipment. The amount borrowed must be between £3,000 and £500,000 and is repayable in up to 48 equal instalments with 0% APR interest.

In order to qualify for an Energy Efficiency loan the initial eligibility of the organisation must be established; it must be an SME and must not fall within a restricted sector. Secondly, the cost-saving and energy saving potential of the proposed project must be determined; the estimated value of the energy saved over 4 years must exceed the loan amount. For full details of the scheme and how to apply visit http://www.carbontrust.co.uk/loan.

Appendix F- Free Cooling

Free cooling is an economical method of using low external air temperatures to assist in either cooling a chilled water loop or purging a building and its fabric of excess and unwanted heat. Although the process has been coined 'free cooling' it should be noted that the cooling provided is not entirely free as the fans and pumps to circulate the chilled water or conditioned air still need to operate however the savings involved in not operating the compressors is substantial.

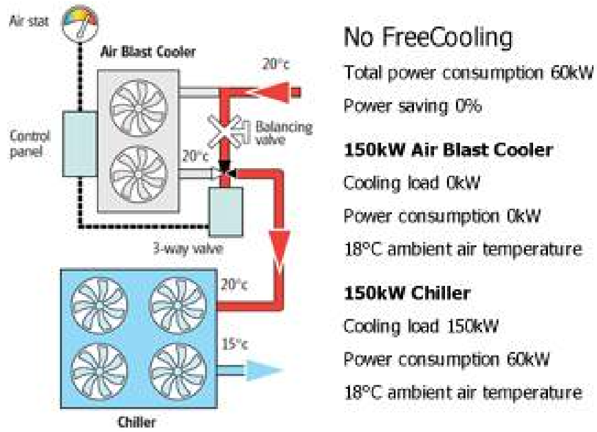
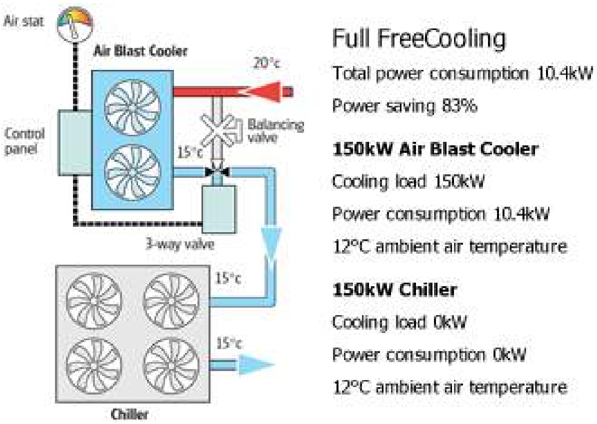


Figure F-1 - No FreeCooling



Water chiller systems are selected to supply a constant water temperature in the Summer time and to achieve this they utilize a high energy use compressor. As most of the year UK ambient temperatures are much cooler, chillers are inevitably oversized for over 70-80% of their operating time over the year. By retrofitting a Free Cooler in a system that utilises a chiller to remove heat from a chilled water loop, the return water is automatically diverted through the free cooler, before entering the chiller, where it is pre-cooled thereby reducing the load on the chiller and the energy being consumed by the compressors.

Figure F-2 - Full FreeCooling

Night time purging via an Air Handling Unit (AHU) is another method of providing free cooling by removing heat loads from the building fabric, as well as the internal space, reducing the energy required to maintain comfort levels within the occupied space the following day. Although it is preferable to use a dedicated supply/extract fan setup, so as to reduce pressure drop within HVAC plant and, in turn, increased fan energy consumption, utilising an AHU to circulate cool ambient air throughout a building with sufficient thermal mass could reduce peak daytime internal temperatures by 2-3°C reducing energy costs related to air conditioning by up to 12%.

Certain free cooling equipment is also covered by the 'ECA Scheme' and comes with substantial financial benefits to be considered:

> *"A business that spends £100,000 on designated energy-saving equipment can deduct £100,000 from their taxable profits of the period in which the spending is incurred. Expenditure on the provision of plant and machinery can include not only the actual costs of buying the equipment, but other direct costs such as the transport of the equipment to site, and the direct costs of installation."*
>
> *HM Revenue & Customs*

Appendix G - ClimaCheck

With 15-20% of total world energy consumption being used for air conditioning and refrigeration purposes, the cooling electricity costs for supermarket and building operators often represents 40-60% of the entire bill. With the majority of cooling systems not working as efficiently as they should, resulting in increased energy costs & carbon dioxide emissions, there is a clear requirement to reduce power consumption and provide a clear picture of how the system is working. It has previously been difficult to cost effectively measure the performance of refrigeration systems in operation however, now there is the ClimaCheck method.

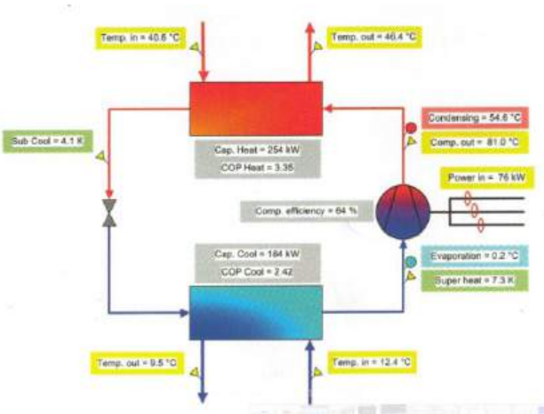


Figure G-1 - ClimaCheck Flow Diagram

The ClimaCheck method allows an owner, installer, consultant or manufacturer to analyse and evaluate virtually all types of air conditioning and refrigeration systems. In a basic cooling process, ClimaCheck directly analyses data, based upon ten measuring points that are connected to the system, and documents the system performance providing a complete picture of how the system is working and any adjustments that may be needed to boost energy efficiency. The ClimaCheck method is based entirely on thermo-physical data for the refrigerant and fundamental energy laws ensuring that any documented performance data is independent of system input or component supplier and is therefore totally unbiased.

The ClimaCheck total solution is available in 2 approaches that offer flexibility and continuity:-

For quick system measurements and adjustments during service or inspection visits there is the 'portable field case' version. Within 30 minutes of connecting sensors, you'll have a complete analysis and documentation of plant performance and all component functions, providing the client with immediate and exact evidence of how well the heat pump, refrigeration or air conditioning system is operating.

Figure G-2 ClimaCheck Portable

Figure G- 3 - Climacheck Fixed

A 'fixed installation' provides continuous monitoring of energy consumption as well as compressor and system performance. End user staff members, service companies and consultants can log in via the Internet and access real-time information about the plant's energy consumption through pre-defined energy reports. An added benefit of a fixed installation is that if the compressor efficiency drops, a refrigerant leak develops or the energy profile falls out of the norm, ClimaCheck will send an alarm in the form of email or SMS to a responsible person who can log in directly from a computer and assess the issue in full. For further details contact your inspection company.

ClimaCheck

Appendix H - AHU Refurbishment

The refurbishment of existing air-handling equipment whilst remaining on site is practical at so many levels that it is considered by many engineers as the first option, rather than strip out and replace with new. Refurbishment can be utilised to repair or replace all areas of an AHU plant including, roof, door & hatch replacement, heating & cooling coils, dampers, filters & filter housing, fans & ductwork.

The benefits of AHU refurbishment include:

- Improved Reliability Of Systems
- Extended Life Span Of Units
- Minimal Disruption To Site Operations

In addition to these benefits, typically the cost of refurbishing an existing unit is between 35-50% of the cost of new equipment and with the introduction of energy efficient technologies, such as EC plug fans and low loss filters, the plant operating costs can also be significantly reduced.

Figure H-1 - EC Plug Fan Upgrade

EC Plug Fans

Electrically commutated (EC) plug fans use a brushless EC motor in a backward curved motorized impeller (plug fan). An EC motor is actually a DC motor that can be connected to an AC supply line with speed control achieved by varying the control voltage from zero to 10 VDC. Tests carried out on plug fan assemblies by ASHRAE indicated an energy saving of up to 18% in relation to a centrifugal fan assembly fitted with a Variable Speed Drive (VSD). This is due to the wheel design and because direct drive motors eliminate losses due to belt slip which can be as much as 5%. As well as reducing energy costs, this technology can also allow for an ROI of less than 12 months in most cases.

Figure H-2 - Variable Speed Drive

Variable Speed Drives (VSD)

Although EC plug fans are generally more efficient than a centrifugal fan with VSD configuration, the initial cost of a plug fan assembly is higher. If the budget for refurbishment is a little tighter, then options of equipping a fixed speed fan assembly with an energy saving VSD should be considered. Whilst there are a number of variations in VSD design, they all offer the same basic functionality which is to convert the incoming electrical supply of fixed frequency and voltage into a variable frequency and variable voltage that is output to the motor with a corresponding change in the motor speed and torque. The motor speed can be varied from zero rpm through to typically 100-120% of its full rated speed whilst up to 150% rated torque can be achieved at reduced speed. VSDs are typically 92-98% efficient with 2-8% losses being due to additional heat dissipation and using a VSD to slow a fan or pump motor from 100% to 80% can save as much as 50% on energy use so an ROI could be realised in short time.

It should be noted that in applications where a reduced output is required but which remains constant it may be more appropriate to install smaller fixed speed equipment.

Appendix I - Heat Recovery

Heat recovery can be defined as the collection and re-use of heat arising from a process that would otherwise be lost. In most processes some of the energy will be lost as heat either as incidental, such as the heat lost through a compressed air system, or accidental, such as heat lost through building fabric. Most buildings using energy for heating, cooling, ventilation or any sort of industrial process have the potential to benefit from the application of heat recovery devices and systems, especially as heat recovery can potentially be applied to any HVAC system that uses ductwork to supply and extract ventilation air.

The main types of heat recovery for an HVAC system are:

- Thermal Wheels
- Plate Heat Exchangers
- Run Around Coils

Thermal Wheel

A thermal wheel, also known as a 'rotary' or 'regenerative' heat exchanger, typically comprises a circular wheel with a matrix or honeycomb material of a large surface area through which air can pass. As the thermal wheel rotates, energy from the exhaust air stream is captured within the honeycomb structure and the energy is transferred to the fresh air stream in the other half of the AHU. Thermal wheel technology offers the greatest percentage of heat recovery within an air system (up to 85%), and therefore the greatest reduction in energy costs, however, there are limitations due to the physical size of the unit as well potential for cross-contamination of the air streams.

Plate Heat Exchangers

By far the most common form of air-to-air heat recovery, plate heat exchangers are formed from a series of parallel plates of aluminium, plastic, stainless steel or synthetic fibre. The supply and extract air streams cross over each other, but are separated by the parallel plates, which allow energy to be transferred from the exhaust air to the incoming air supply providing efficiencies of between 50-80% depending on the unit specification. This technology can also be linked with additional heating and cooling coils to reduce the amount of energy required to maintain internal conditions.

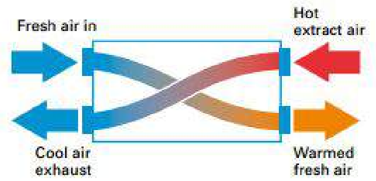


Figure I-1 - Plate Heat Exchanger

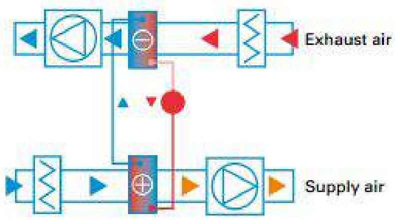


Figure I-2 - Run Around Coils

Run Around Coils

Run around coils are a process where heat or cool energy is removed from one location and directed to another where the systems cannot be located within the same AHU or to avoid cross-contamination of air. The possibility of exchanging heat between remote air streams is due to the coils being connected to each other by a pumped pipe work circuit. This pumping will use a small amount of energy but this will be less than that being saved by installing the system allowing for efficiencies between 45 -55%. Additional efficiencies of up to 75% can be realised if linked to a separate heat source.