TECHNICAL FACT SHEET 2
EDSL Tas ENERGY STUDY
SUMMARY FINDINGS

June 2013

Foreword

This study has been independently modelled by Environmental Design Solutions Ltd. (EDSL) to provide a fair comparison of energy efficiency. The EDSL Tas (Thermal Analysis Software) version 9.2.1.6 has been used to create models of buildings to effectively simulate their dynamic thermal performance; the EDSL Tas software is fully accredited by the DCLG (Dept. of Communities and Local Government) for part L and EPC (Energy Performance Certificate) calculation. The completed simulations are dynamic and have used CIBSE published hourly weather data for London and Birmingham to simulate thermal performance; the weather data are representative of an average year over the last 20 years.

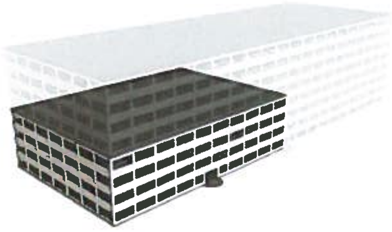
Introduction

The purpose of this study is to compare the energy consumption, CO2 emissions and running costs for a selection of HVAC systems; the systems being analysed are:

- VAV Fan Coil with EC motors
- Passive Chilled Beams (95% Convective, 5% Radiant)
- Active Chilled Beams

The Building Models

The study consists of four differently sized office building models each based on an open plan office with small core area's with WC's in the centre, each building has Part L2 Notional constructions and glazing percentages; the different building model sizes are as detailed below:-



Building 1

Building 2

Building 3

Building 4

Reference	Building 1	Building 2	Building 3	Building 4
Footprint	35m x 50m	35m x 50m	35m x 100m	35m x 100m
Storeys	4	8	4	8
Approximate Office Space	7000m²	14000m²	14000m²	28000m²

Fig 1 & Table 1. Building Model Sizes

The building has been zoned as specified in the NCM modelling guide and incorporates 6m perimeter zones which enable the different solar gains to be modelled and analysed; the building floor layouts can be seen below in figures 2 & 3:-

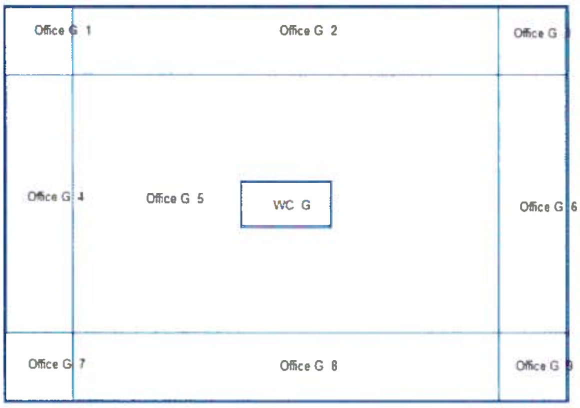


Fig 2. Floor Plan for Buildings 1 & 2

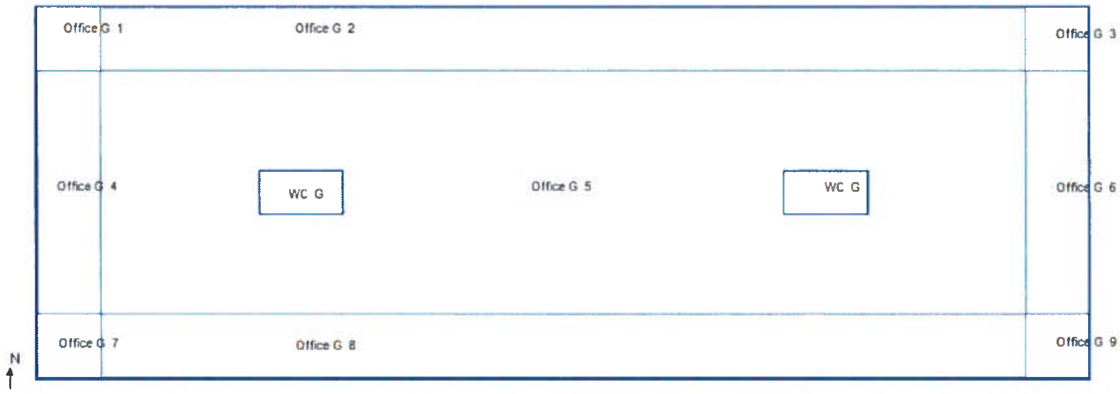


Fig 3. Floor Plan for Buildings 3 & 4

The internal gains for the offices are listed below:

Lighting gain = 12W/m2
Occupancy sensible gain = 8.4W/m2
Occupancy latent gain = 6.3W/m2
Occupant density = 1 person per 10m2
Fresh air requirement = 12 l/s/person
Equipment sensible gain = 17.5W/m2
Schedules as per NCM internal office condition
Heating and cooling set point as per NCM internal office condition

There are no opening windows and infiltration is 0.13 ACH.

The System Modelled

All three HVAC systems included a high efficiency chiller which supplies chilled water to the terminal units being analysed. An air source heat pump supplies heating and cooling to the DX coils in the AHU which includes heat recovery; the AHU for all systems is sized to provide the minimum fresh air requirements in accordance with NCM methodology for an internal office environment.

The system variables for the selection of HVAC systems analysed can be seen below in table 2.

System Variable	VAV Fan Coil	Passive Chilled Beam	Active Chilled Beam
Chilled Water Flow	6.0 °C	14.0 °C	14.0 °C
Chilled Water Return	12.0 °C	17.0 °C	17.0°C
AHU SFP*	2.1 W/l/s	2.1 W/l/s	2.1 W/l/s
AHU Heat Recovery	75%	75%	75%
AHU Air Supply Temperature	14.0 °C	18.0 °C	16.0 °C
Chiller COP	4.00	4.48	4.48
Free Cooling DAC Efficiency	67%	67%	67%
Free Cooling SFP	0.4 W/l/s	0.4 W/l/s	0.4 W/l/s

* to achieve the same SFP each system will have different sizes of AHU and ductwork.

Table 2. System Variables

All systems included a boiler with an efficiency of 90% and DX performance was taken from typical Mitsubishi VRF heat recovery unit.

The Fan Coil Units include EC motors and VAV control and have an SFP of 0.25 W/l/s, the fan curve applicable can be seen below in figure 4.

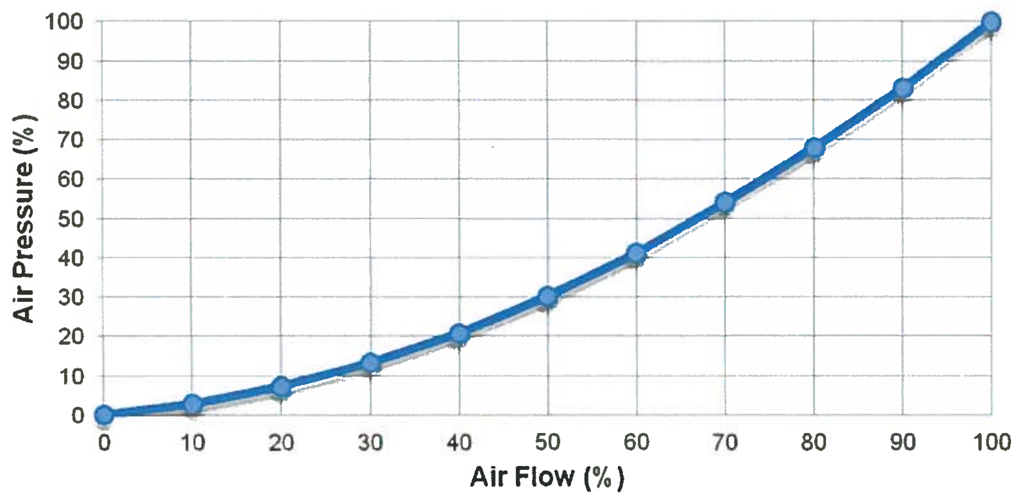


Fig 4. Fan Curve for VAV Fan Coil Terminal Fan

Results

The HVAC systems monthly consumption figures for Building 1 (London) can be seen below in figure 5:-

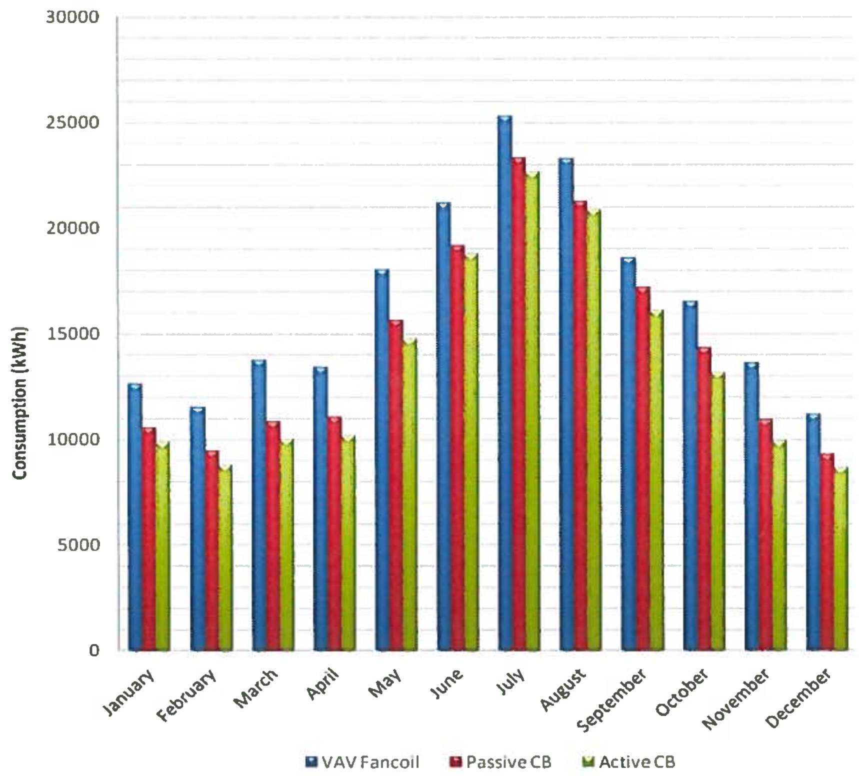


Fig 5. Building 1 Monthly Plant Energy Consumption.

The breakdown of the annual plant consumption in Building 1 (London) for the systems analysed can be seen below in Figure 6:-

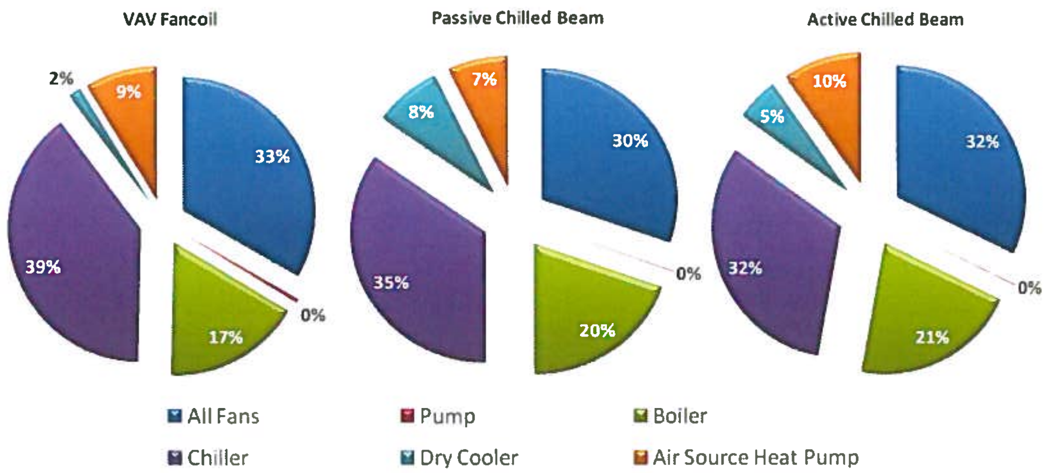


Fig 6. Building 1 Yearly Consumption Breakdown for each HVAC system.

The annual HVAC plant energy demand and required number of HVAC emitters for all the buildings modelled can be seen below in tables 3 and 4:-

Building No	Location	Demand (kWh)		
		VAV Fan Coil	Passive Chilled Beam	Active Chilled Beam
1	London	501,716	428,883	406,599
	Birmingham	433,078	344,774	326,112
2	London	1,041,509	876,728	832,060
	Birmingham	901,858	703,116	665,659
3	London	997,675	842,179	797,498
	Birmingham	862,033	676,255	638,748
4	London	2,076,364	1,724,439	1,634,948
	Birmingham	1,800,121	1,381,600	1,306,347

Table 3. The Annual Demand of the HVAC Systems Simulated

Building No	Location	Emitters Required to Meet Peak Demand		
		VAV Fan Coil (Qty)	Passive Chilled Beam (linear m)	Active Chilled Beam (linear m)
1	London	121	1107	454
	Birmingham	123	1070	437
2	London	250	2273	934
	Birmingham	254	2202	893
3	London	354	3242	1327
	Birmingham	356	3143	1291
4	London	466	4277	1751
	Birmingham	473	4149	1675

Table 4. The Required Quantity of Emitters to Meet Peak Demand

The annual HVAC plant energy consumption & CO2 emission results for all the buildings modelled can be seen below in table 5 and figures 7 and 8:-

Building No.	Location	VAV Fan Coil		Passive Chilled Beams		Active Chilled Beams	
		Consumption (kWh)	Co2 Emission (kg)	Consumption (kWh)	Co2 Emission (kg)	Consumption (kWh)	Co2 Emission (kg)
1	London	198897	92203	173037	78644	163756	73828
	Birmingham	185447	84217	159717	70747	150598	66002
2	London	404008	189191	346557	159182	327919	149525
	Birmingham	375536	172884	317825	142774	299479	133244
3	London	392231	183131	338129	154846	319457	145177
	Birmingham	365010	167389	311031	139187	292599	129630
4	London	800175	377178	679824	314497	642348	295106
	Birmingham	742509	345003	621389	281945	584320	262748

Table 5. HVAC Plant Annual Consumption and CO2 Emissions

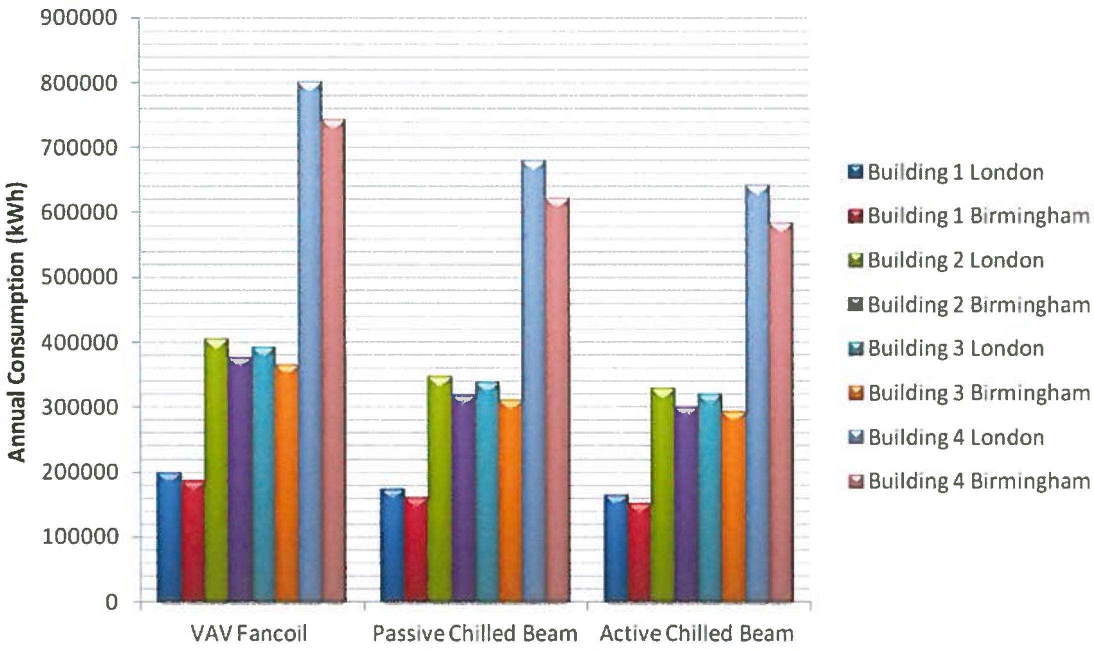


Fig 7. HVAC Plant Annual Consumption

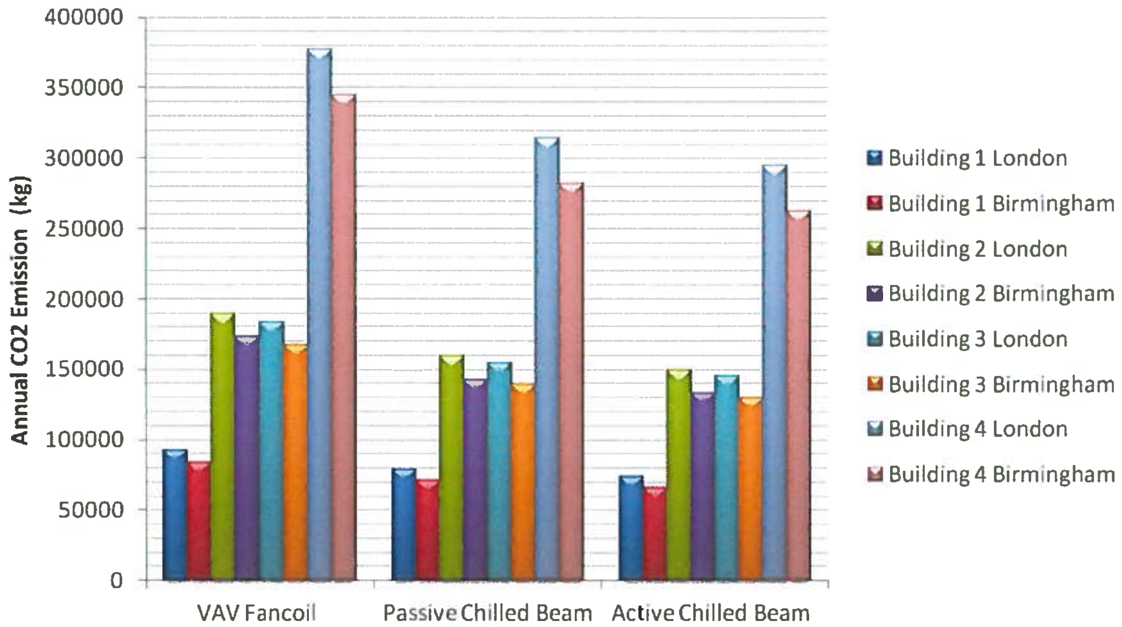


Fig 8. HVAC Plant Annual CO2 Emission

The annual HVAC plant energy running costs can be seen below in table 6 based on 13p/kWh for electricity and 5p/kWh for gas.

Building No	Location	Annual Plant Energy Cost (£)		
		VAV Fan Coil	Passive Chilled Beam	Active Chilled Beam
1	London	£22,463	£19,158	£17,984
	Birmingham	£20,516	£17,232	£16,076
2	London	£46,093	£38,779	£36,425
	Birmingham	£42,117	£34,779	£32,456
3	London	£44,616	£37,722	£35,366
	Birmingham	£40,778	£33,905	£31,575
4	London	£91,894	£76,617	£71,892
	Birmingham	£84,051	£68,682	£64,004

Table 6. Annual Plant Energy Costs for the HVAC systems analysed.

The annual plant energy running costs savings achieved using chilled beams can be seen below in figure 9; the chart is split for each particular building and shows the available annual running cost saving expressed as a percentage against the VAV Fan coil system benchmark (100%):-

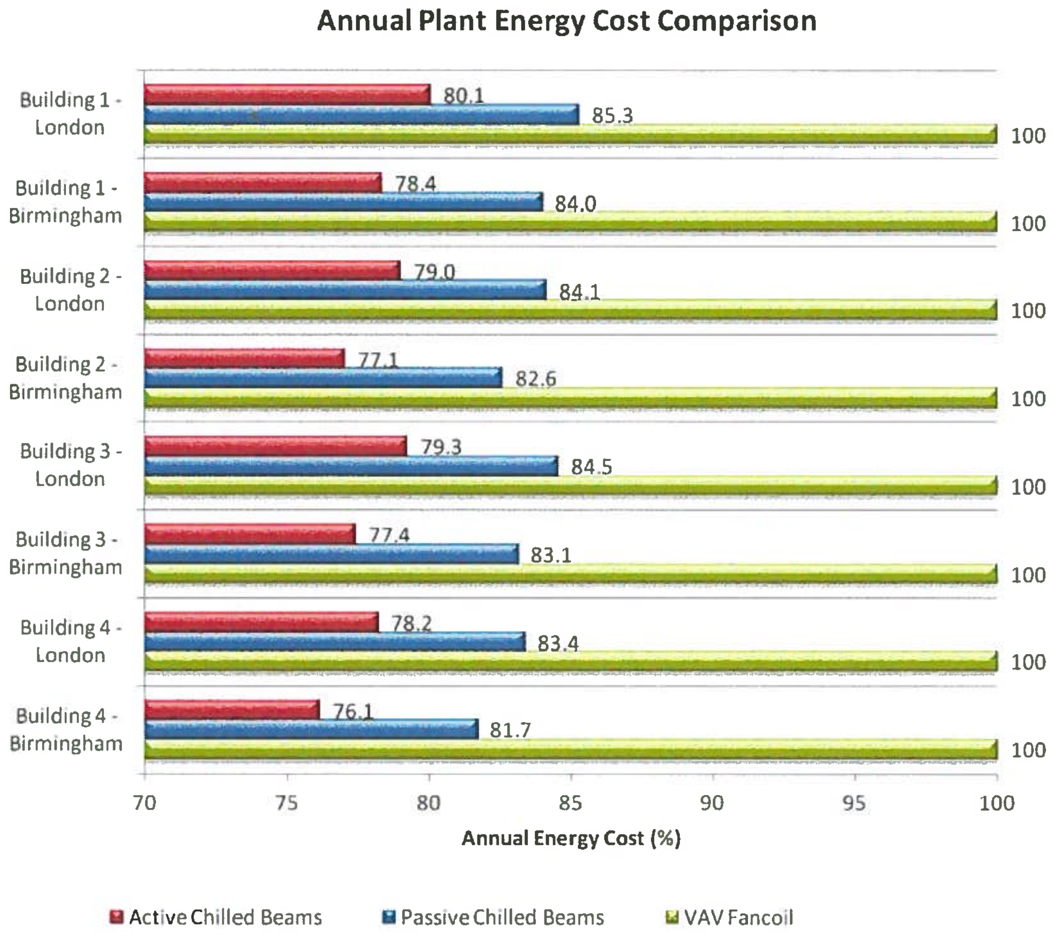


Fig 9. Relative Plant Energy Running Costs Expressed as a Percentage.

The completed energy study modelling clearly shows that both the Passive and Active beams energy consumption is lower than that of the VAV Fan Coil system; the average annual energy cost saving, over all the buildings for both locations is approximately 17% annual for the passive chilled beam system and approximately 22% for the active chilled beam system over the VAV fancoil system modelled.

The passive chilled beam systems energy consumption is slightly higher than the active beam system primarily because the passive beams displacement ventilation system requires a higher fresh air supply temperature (in order to meet occupant comfort) than that of the active system and that both systems had the same fixed AHU SFP's; the increased air supply temperature on the modelled displacement ventilation system results in increased energy usage on the fresh air re-heat DX circuit and also results in less airside cooling being available, therefore during certain times of the year where outside conditions effectively allow the active beam systems to have a higher level of "free" airside cooling than a passive system, whereby the passive system will have to make up any shortfall of airside cooling via waterside cooling which results in a slight increase in the chiller energy consumption.

Elevated Chilled Water Temperatures

Additional energy savings can be achieved by increasing the chilled water flow and return temperatures to the chilled beam units; the relationship between chilled water flow temperature and Chiller coefficient of performance (COP) as modelled can be seen in figure 10.

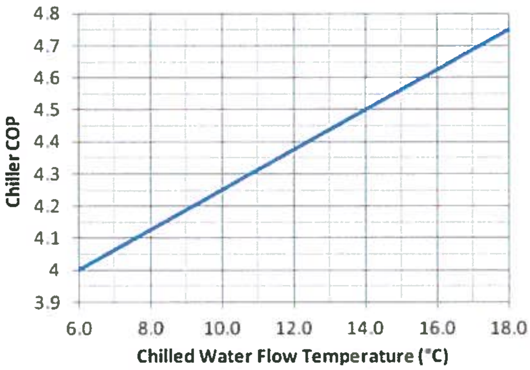


Fig 10. Relationship between Chilled Water Flow Temperature and Chiller COP.

The following graphs detail the increased annual plant energy saving expressed as a percentage for both Buildings 1 and 4 in London and Birmingham if the chilled water flow temperature is increased above the benchmark for each system (6°C for VAV Fancoil and 14°C for chilled beams); the energy savings are all based upon the chilled water return temperature being 6°C higher than the chilled water supply temperature for VAV Fancoils and 3°C higher than the chilled water supply temperature for chilled beams:-

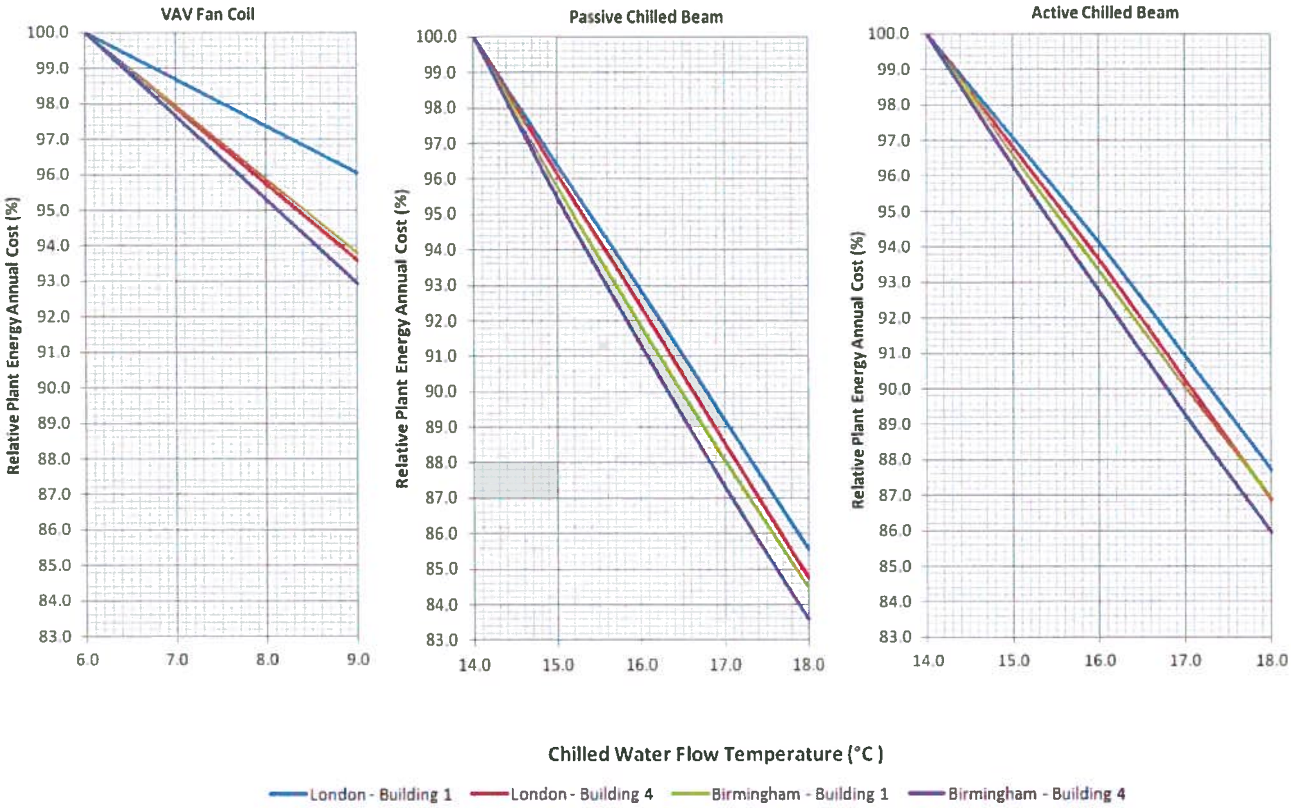


Fig 11. Additional Plant Energy Cost Saving Expressed as a Percentage

Summary of Energy Modelling – Plant Energy Cost Per Sq. M

Based upon the average data calculated for Buildings 1 and 4 (in London and Birmingham) the average plant running costs per m2 of office space for both standard and elevated water temperatures can be seen below in figure 11:-

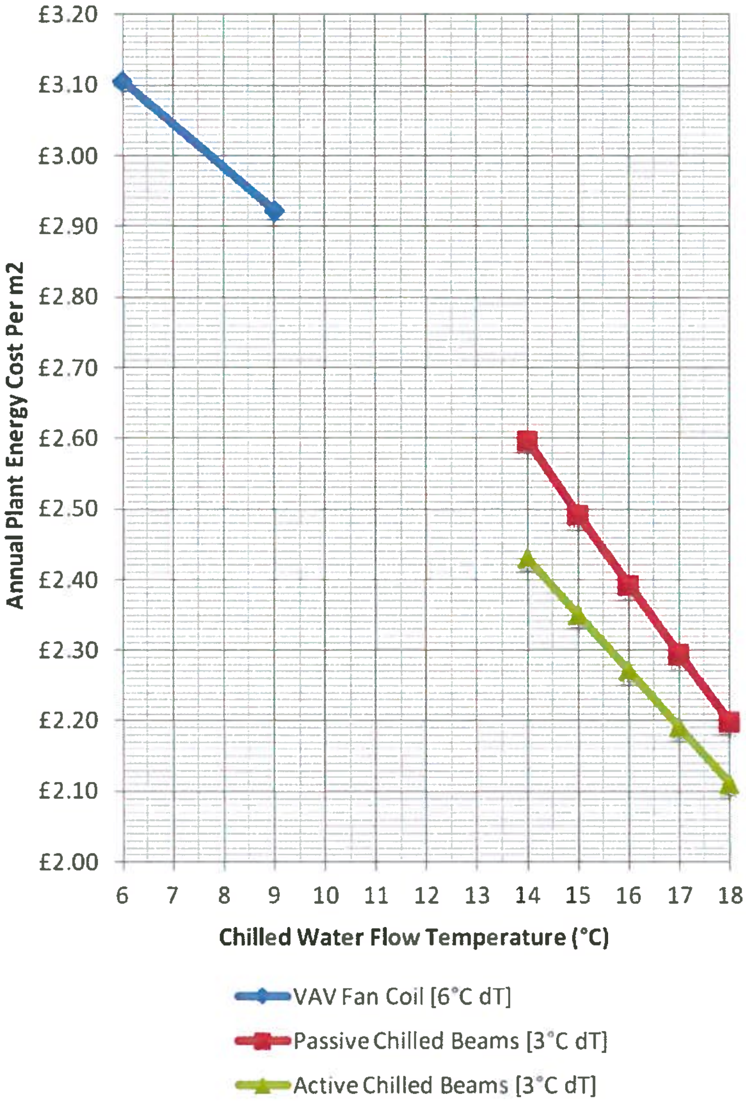


Fig 11. Annual Plant Energy Running Cost per m2 of Building