Carbon Footprint Assessment

for

Dumfries & Galloway College

(Dumfries Campus)

A Report by:

crichton **carbon** centre

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TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

TABLES

FIGURES

1 Executive Summary

In 2009, Dumfries and Galloway College (Dagcol) signed the Universities and Colleges Climate Change Commitment for Scotland, acknowledging that it will take action to reduce its greenhouse gas emissions. To fulfil the commitment the College must calculate its baseline carbon footprint and produce a five-year action plan which is to be completed by February 2010.

An energy and water audit was carried out for the Dumfries main campus building (gas, electricity) and the Edinburgh Road workshop (gas, electricity), which is leased by Dagcol. A building audit was also carried out for the main campus building. The baseline footprint year encompassed the period 1 August 2008 to 31 July 2009. The headline messages from the report are summarised below:

- Dumfries' total Scope 1 (direct energy and fugitive emissions) and Scope 2 (indirect energy emissions) GHG emissions were **1,154 tCO_2eq** (1,153,593 $kgCO_2eq$) in the 2008/09 baseline year. This takes into account natural gas consumption, electricity use and fugitive emissions from air conditioning and refrigeration.

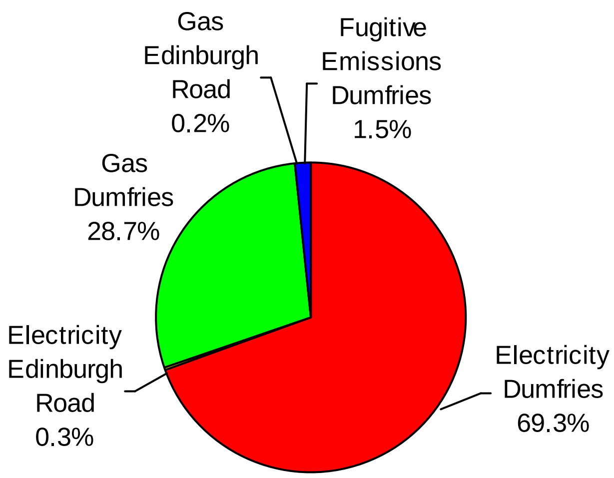

Figure 1.1: Breakdown of Total Emissions Produced by Dumfries Campus Scope 1 and 2 Sources in 2008/09 Baseline Year

- As shown in **Figure 1.1**, the majority of GHG emissions were generated by electricity consumption (69%) and gas use (29%). However, it should be noted that gas consumption data is estimated and was not taken from invoices.
- Supply chain GHG emissions resulting from the extraction, production and transportation of fuels were accounted for separately and totalled **1,732 tCO_2eq** (1,731,510 $kgCO_2eq$) in the 2008/09 baseline year. This takes into account gas and electricity consumption.
- Data gaps were identified in relation to the availability of gas and water invoices for the main campus building with all being unavailable (not provided by supplier).

As a result of the baseline footprint calculations and conversations with Dagcol's Estates team, several recommendations have been suggested to reduce, or enable the reduction of the GHG emissions generated through energy consumption. The main recommendations and observations are highlighted below:

- The Dumfries campus building is new and meets 2007 Building Standards. Monitoring and control of the building temperature could be further improved by reviewing the five control zones and temperature set points, and using the building management system to examine its performance.
- Energy efficient lighting has been installed throughout the Dumfries building, which is positive in terms of energy consumption. However, the lighting levels within the main building seem high. These should be measured and compared with recommended levels.
- There is the potential to reduce the number of T5 fluorescent bulbs by removing one from every double fitting (or equivalent action, such as placing every other light fitting on a separate switch). This has the potential for a one-off reduction in electricity consumption of **94,000 kWh**. This is equivalent to **£10,500** and GHG emissions of **51 tCO_2eq** (51,000 $kgCO_2eq$). Removing bulbs should be tested to gauge the effect on the performance of staff and students before being widely implemented.
- Dagcol has a progressive policy in relation to the procurement of energy efficient electrical equipment. This helps to reduce the quantity of electricity consumed by the Dumfries campus and should continue. This could be enhanced further through the promotion of behavioural change actions to staff and students, such as switching off PC monitors when not in use. For example, there is the opportunity to reduce power consumption through the staggered shutdown of PCs outside core student hours, and reprographics photocopiers are being left on standby overnight rather than being switched off at the end of the day.

2 Introduction

In 2009, the Scottish Government committed the country to an 80% reduction in greenhouse gas (GHG) emissions by 2050, compared with 1990 levels, with an interim target of 42% by 2020[1]. To assist in achieving this goal 47 universities and colleges, including Dumfries and Galloway College (Dagcol), have signed up for the **Universities and Colleges Climate Commitment for Scotland**. In signing the commitment the institutions acknowledge that GHG reduction should form an integral part of the strategic planning process.

Under the commitment, the baseline carbon footprint of Dagcol must be assessed and GHG emission reductions identified. Once this has been completed, a 5-year action plan, with targets and timescales, must be compiled and published by February 2010. In addition, measures must be taken to engage all staff and students in this process, enabling them to become involved in reducing Dagcol's carbon footprint.

When calculating an organisation's carbon footprint it is necessary to establish a baseline year and set the boundaries of the analysis. The baseline year for the carbon footprint has been selected as the 2008/09 financial year of 1 August 2008 to 31 July 2009. The baseline carbon footprint assessment will include emissions of the 'Kyoto basket of 6' greenhouse gases (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride) arising from the activities of the College across the Dumfries and Stranraer campuses. This report addresses emissions associated with the Dumfries campus from the sources detailed below. A survey was also carried out of lighting and electrical equipment utilised at the campus. Energy use at the leased Edinburgh Road premises (gas and electricity) is also assessed. Using this data, basic recommendations for areas where improvements can be made will be highlighted using illustrative examples where possible.

Emissions associated with the Stranraer campus, travel (fleet vehicles, business travel and commuting), and waste disposal are addressed in separate reports.

2.1 Emission Sources included in this Assessment.

Scope 1 – direct emissions from sources that are owned/controlled by Dagcol

Direct energy consumption – on site consumption of gas for space and water heating, teaching (gas assessment centre) and catering

Fugitive emissions – leakage of refrigerant gases from air conditioning/refrigeration equipment (Dumfries campus only)

Scope 2 – indirect energy emissions generated in the production of electricity

Purchased electricity consumed

Scope 3 – other indirect emissions

Embodied emissions from extraction, production and transportation of fuels

Line loss from electricity transmission and distribution

Water supply and waste water treatment (Dumfries campus only)

[1] Scottish Parliament (2009) Climate Change (Scotland) Act

3 Dumfries Campus – Building and Utilities Survey

The Dumfries campus of Dagcol is a relatively new building; officially opening in September 2008 (construction began in 2007 and was completed in December 2008). Consisting of four stories, it includes a number of facilities, including classrooms, offices and workshops, as well as areas for catering and sports. The campus currently hosts 3475 full- and part-time students, as well as employing over 300 staff. The campus runs a range of courses, from art to information communications technology and plumbing. In total 68 full-time courses are offered in the 2009/10 academic year, as well as a range of open-learning and night classes.

3.1 Building Survey – Fabric and Heating

A selective building survey was carried out by Mark McKenna (Project Manager - CCC) on Thursday 3 September 2009, with a building tour and explanation of the heating system given by Ian Richardson (Electrician/Maintenance Co-ordinator – Dagcol). This involved a non-invasive inspection of the main building, within the boundaries of the property. The main findings are summarised below and a copy is provided as a separate report.

The main findings of this survey were:

- The building fabric meets 2007 Building Standards, using 150mm mineral wool insulation with a U-value[2] equal or less than 0.25W/m²K. Current building regulations (Scottish Building Standards Agency 2009) require new external wall construction should achieve a U-value equal or less than 0.20W/m²K.
- All glazing is double-glazed. Staff offices experience hot temperatures in the summer months due to solar radiance, resulting in heat build-up. There are moderate shading blinds on all windows, which provide shade but do not protect from heat build-up.
- The building space is heated by 3 gas fuelled 'Ecoflam' boilers, which are timed to come on between **5am and 12pm (noon)**. The number of boilers that are in operation depends on the return temperature into the first boiler. There is also an optimisation setting, which means that the boiler(s) will switch off when the desired temperature is reached, which is set at the control centre. This is influenced by the wall thermostats that are placed around the building.
- The building consists of five zones (1-6, no 5), which are heated by radiators, vent heaters and ceiling panels. These are controlled by constant control temperature circuits and variable control temperature circuits.
- In public spaces, the constant temperature set for heating purposes is 18°C, however the true temperature is 20-21°C. This is due to high occupancy and heat generated by equipment, such as computers. A higher temperature of 24°C is set during the winter months due to the colder outside air temperature and resulting heat loss as people move in and out of the building. The Henry Duncan Building has a separate heating system, consisting of an electricity supplied air handling unit, which heats the outside air to 18°C.
- The building is cooled using two methods, a Passive Vent System and an Air Handling Unit (AHU) System. The former is utilised in the public spaces, such as

[2] A u-value is the measure of heat-loss from a building's internal and external walls, with a lower u-value indicating better insulation of the building.

the cafeteria and library area, consisting of five vent zones. The latter comprises of eight AHUs across the building, which covers all closed or controlled areas.

- It was highlighted that students are mostly entering and exiting the main campus building through the disabled access doors, instead of using the revolving door provided.

3.2 Building Survey – Lighting

A survey of the lighting utilised in Dagcol Dumfries campus building was carried out by Lisa Gibson (Project Officer – CCC) using plans provided by Diston Dryburgh (Estates Officer – Dagcol). Further information regarding bulb specific power consumption was supplied by Ian Richardson (Maintenance Coordinator – Dagcol). For a full list of bulb types, see **Appendix A**.

A variety of light fittings are used in the building, with the majority being luminaries for fluorescent strip bulbs. Paired T5 low energy fluorescents (28W) are used throughout the building, including offices, classrooms, corridors, interview rooms and workshops. In work areas, the T5 bulbs are used with reflector fittings to enhance the quantity of light received from them. In addition passive infra red (PIR) sensors are utilised in the majority of classrooms, offices and store rooms. This ensures that lights are switched off when rooms are not in use. Other bulb types used for lighting are all low wattage, with the exception of 150W metal halide bulbs used in the main entrance exterior and the high level down lights in the library.

3.3 Energy – Gas

The major use of mains gas at the Dumfries campus is space and water heating, with a minor secondary use in the gas assessment centre. Gas consumption data is unavailable for the 2008/09 baseline year. This is due to invoices for the meter point being incorrectly directed to the NHS by the gas supplier. Diston Dryburgh has repeatedly contacted the original gas supplier to try to rectify this situation; however these attempts have been unsuccessful. In any case, the Dagcol Estates team has expressed concerns that the gas consumption data for the baseline year would not represent business as usual (BAU). This is due to the contractor handover period and the completion of building work before practical completion in December 2008. It was also highlighted that there have been problems with the gas assessment centre within the building due to supply pressure fluctuations.

To address this data gap, gas meter readings (meter no. M0300A055107D) have been taken on an approximately weekly basis from 31 July 2009 to 15 December 2009. It has been assumed that gas use in this period represents BAU (heating demand for a given outdoor air temperature). Combining this consumption data with the daily degree day record from the Eskdalemuir meteorological station allows a back estimate of gas consumption in the baseline year (due to standard heating demand and excluding any addition gas use due to construction) of approximately **1,800,000 kWh** (1,800 MWh). This estimated gas consumption would result in GHG emissions **331.1 tCO_2eq** (331,128 $kgCO_2eq$). Applying the charge of £0.02031p per kWh[3], this quantity of gas use would have an estimated cost (excluding VAT or Climate Change Levy) of **£36,558**. It is noted

[3] Per unit charge by new supplier, Eon.

that this estimate carries a relatively high uncertainty. For further information on degree days and the calculation of this estimate, please see **Appendix B**.

The gas supplier has now changed to Eon with the first invoice dating from 1 August 2009.

3.4 *Energy – Electricity*

Dumfries campus electricity consumption data was supplied by Diston Dryburgh for the 2008/09 baseline year in the form of invoices. Electricity is monitored through one meter (no. P07A2204918000054840528), and was supplied by EDF Energy in the 2008/09 baseline year.

Electricity consumption, associated costs, and GHG emissions for the baseline year are given in **Table 3.1**. During the baseline year, **1,469,215 kWh** (1,469 MWh) of electricity were consumed, at a total cost of **£242,535** (including fixed costs, energy consumption charges, the Climate Change Levy and Value Added Tax). This purchased electricity resulted in GHG emissions[4] of **799.5 tCO_2eq** (799,517 $kgCO_2eq$). Of this, **738.1 tCO_2eq** (738,104 $kgCO_2eq$) were emitted due to electricity generation, and **61.4 tCO_2eq** (61,413 $kgCO_2eq$) due to transmission line losses.[5]

Presently, the Dumfries campus is charged for electricity using five different tariffs, depending on the time of year, however it is unclear when the switchover time for each tariff occurs (e.g. between day/night tariffs):

- T1 – Night units (£0.12088 per unit)
- T2 – Other units (£0.11102 per unit)
- T3 – Winter weekdays (£0.14888 per unit)
- T4 – Feb-Nov peak (£0.24077 per unit)
- T5 – Dec-Jan peak (£0.26511 per unit)

The Climate Change Levy is also applied to electricity consumption at a rate of £0.00456 per kWh in the 2007/08 tax year and £0.00470 per kWh in the 2008/09 tax year respectively.

Figure 3.1 shows the consumption of electricity throughout the baseline year. It has been highlighted by the Estates team that electricity consumption for the months running up to December 2008 may not represent BAU. This is due to contractors working on the site at the evenings and weekends. There are indications of this in **Figure 3.1**, with slightly elevated electricity consumption in October and November when compared to January and February. It is also noted that the low consumption in August 2008 was before the official opening of the College in September. Examining the second half of the year, the overall trend in consumption indicates highest usage in winter, decreasing slightly in spring, and comparatively low usage in summer (absence of students). This trend reflects building occupancy, lighting demand, and heating demand, with the possible use of additional electric space heaters in the winter months.

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[4] Includes total GHG emissions (CO_2, CH_4, N_2O)

[5] A proportion of generated electricity is lost during transmission through the National Grid due to processes such as the resistive heating of transmissions lines and resistive losses in transformers (National Grid, 2008). Emissions associated with electricity generation and transmission and distribution losses were estimated as per guidance given in appendix 3 of Defra/DECC (2009). In practical terms, this applies the average transmission and distribution losses for the UK National Grid over the 5 year period 2003-2007 (approximately 7.7% of generated electricity lost during transmission).

Date	Fixed charge	Energy Use (kWh)						Energy Charge Sub Total	CCL		VAT	Total Cost	Total GHG emissions		
		T1	T2	T3	T4	T5	Total units		Rate	Cost			Generation	Line Losses	Consumed
	(£)	*0.12208*	*0.11102*	*0.14888*	*0.24077*	*0.26511*		(£)	(£/kWh)	(£)	(%)	(£)	($kgCO_2eq$)	($kgCO_2eq$)	($kgCO_2eq$)
Aug-08	1,315.87	11,959	33,735				45,694	6,521.08	0.00456	208.36	17.5	7,907.10	22,956	1,910	24,866
Sep-08	1,315.87	32,386	100,525				132,911	16,429.84	0.00456	606.07	17.5	20,017.20	66,772	5,556	72,328
Oct-08	1,315.87	37,113	109,864				146,977	18,043.73	0.00456	670.22	17.5	21,988.88	73,838	6,144	79,982
Nov-08	1,315.87	34,159	44,210	54,543	13,573		146,485	21,782.53	0.00456	667.97	17.5	26,379.34	73,591	6,123	79,714
Dec-08	1,315.87	30,112	34,095	51,387		12,862	128,456	19,837.51	0.00456	585.76	15.0	23,486.76	64,534	5,369	69,903
Jan-09	1,315.87	27,759	34,651	61,330		15,569	139,309	21,809.95	0.00456	635.25	15.0	25,811.98	69,986	5,823	75,809
Feb-09	1,315.87	27,790	33,285	61,994	15,601		138,670	21,389.69	0.00456	632.34	15.0	25,325.33	69,665	5,796	75,461
Mar-09	1,354.62	29,964	34,023	84,322			148,309	21,343.72	0.00456	676.29	15.0	25,323.01	74,507	6,199	80,707
Apr-09	1,354.62	26,339	94,441				120,780	15,054.92	0.00470	567.67	15.0	17,965.98	60,677	5,049	65,726
May-09	1,354.62	26,617	101,833				128,450	15,909.52	0.00470	603.72	15.0	18,990.22	64,531	5,369	69,900
Jun-09	1,354.62	22,826	93,145				115,971	14,482.18	0.00470	545.06	15.0	17,281.33	58,262	4,848	63,109
Jul-09	1,354.62	17,098	60,105				77,203	10,114.80	0.00470	362.85	15.0	12,049.30	38,785	3,227	42,012
TOTAL	**15,984**						**1,469,215**	**202,719**		**6,762**		**242,526**	**738,104**	**61,413**	**799,517**

Table 3.1: Electricity Consumption, Spend and GHG Emissions for Dumfries Campus in 2008/09 Baseline Year

Note consumed electricity is the combined total of generated electricity and line loss

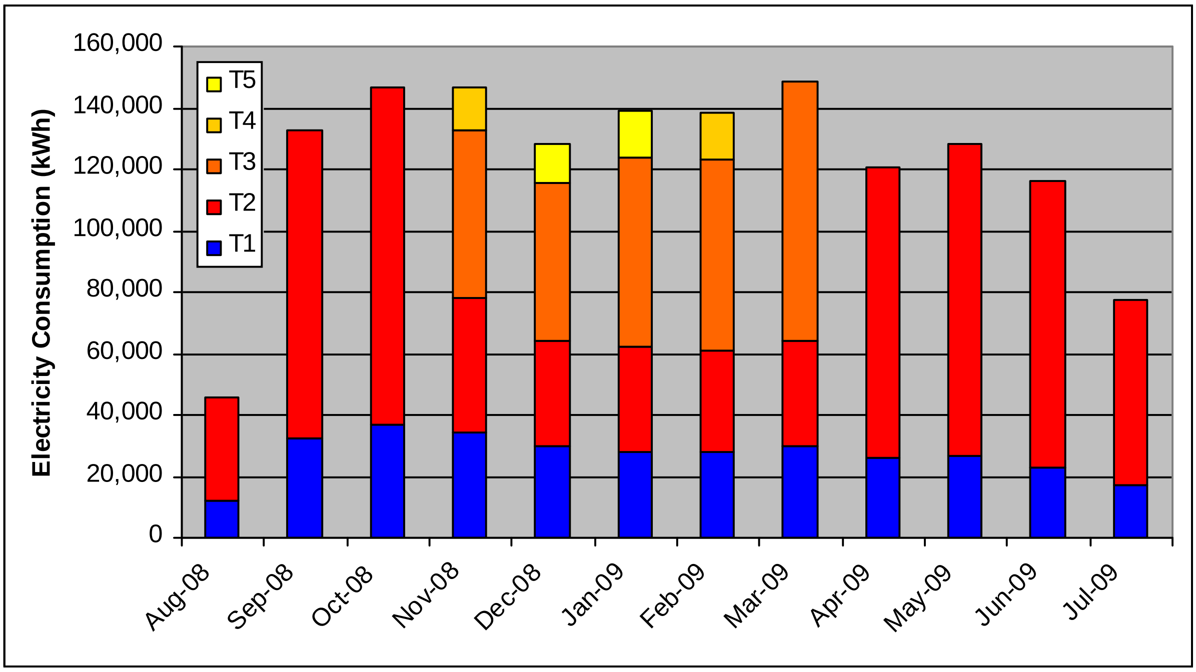

Figure 3.1: Electricity Consumption of Dumfries Campus for 2008/09 Baseline Year

Table 3.2 and **Figure 3.2** shows the fuel mix of electricity sold by EDF Energy in 2007/2008 in comparison to the UK average[6]. The EDF fuel mix has a higher proportion of renewables, is lower in nuclear and gas and higher in coal. Given the GHG emissions intensity of these energy sources (see **Table 3.2**), the dominance of coal results in the overall emissions intensity of electricity supplied by EDF energy being higher than the national average. It is noted that Dagcol has now changed their electricity supplier to Scottish Power. The Scottish Power fuel mix is also shown below in **Table 3.2** and **Figure 3.2**. While the renewable content in the Scottish Power fuel mix is higher than both EDF Energy and the UK average, so is the proportion of coal and gas. The carbon emissions intensity of Scottish Power electricity is therefore higher than both that of the UK average and EDF energy.

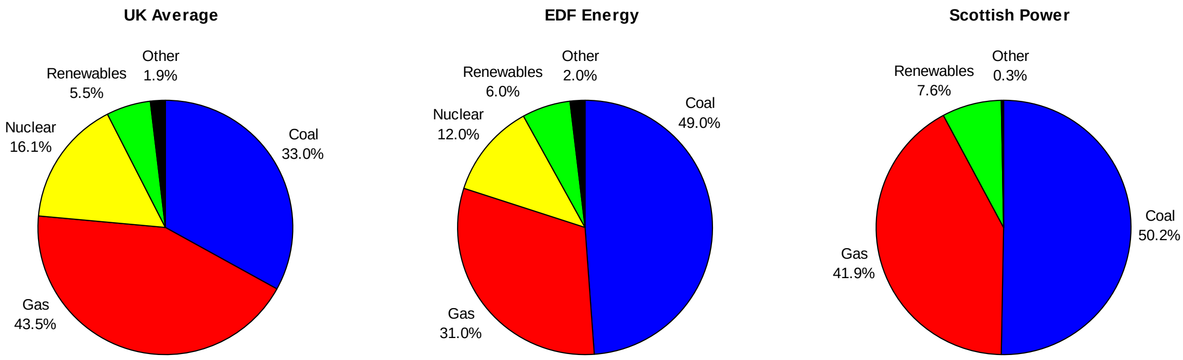

Figure 3.2: 2008 UK Average, EDF Energy and Scottish Power Fuel Mix (Source: www.fuelmix.co.uk)

[6] FuelMix (2009) EDF Energy Fuel Mix Disclosure 2008

Fuel Type	gCO_2/kWh	UK Average	EDF Energy	Scottish Power
Coal	910	33.0	49.0	50.2
Gas	360	43.5	31.0	41.9
Nuclear	0	16.1	12.0	0.0
Renewables	0	5.5	6.0	7.6
Other	610	1.9	2.0	0.3
gCO_2/kWh		468	569	610

Table 3.2: 2008 UK Average, EDF Energy and Scottish Power Fuel Mix (Source: www.fuelmix.co.uk)

3.5 Water Consumption

The consumption of water by the Dumfries campus of Dagcol is metered by and should be invoiced by Scottish Water ever quarter. However, at present no invoices have been provided by Scottish Water; Dagcol have contacted Scottish Water in an attempt to rectify this situation.

The toilet facilities provided for students are geared towards low water use and waste, with a dual-flush system for toilets and push taps. In staff and disabled toilets, the toilets are dual flush and turn taps are used (for accessibility purposes in disabled toilets). There are also sinks in some classrooms, such as those for art, plastering or special needs, however these are the exception rather than the rule.

4 Dumfries Campus - Fugitive Emissions

'Fugitive emissions' refers to the leakage of GHGs from equipment such as air conditioning and refrigeration units. This leakage occurs during installation, daily use, refrigerant gas recharging and eventual disposal. Since the 1990s, hydrofluorocarbons (HFCs) have been used as refrigerants, replacing chlorofluorocarbons (CFCs), due to their ozone depleting properties. HFCs have a global warming potential many times greater than that of CO_2.

The Dumfries campus building has an air conditioning system that is used in a variety of areas, particularly where there are large collections of IT equipment, such as computers and servers. Two types of air conditioning unit are used, 'City Multi' and 'Mr Slim', both of which are recharged using refrigerant R410a[7]. There are six City Multi units, which have a gas charge of 11.8-13.0kg, and eight Mr Slim systems, each having a charge of 5.0kg. In addition there are a number of refrigerators of varying sizes situated throughout the campus building. These are mostly used for catering purposes and for the storage of staff drinks, snacks and meals.

Information about the air conditioning units used at Dumfries, including gas type and charge, was provided by Ian Richardson (Electrician/Maintenance Co-ordinator – Dagcol). In relation to refrigerators situated throughout the building, a survey of

[7] R410a is a 50:50 blend of HFC-32 and HFC-125, which has a global warming potential of 1,725.

equipment was carried out in September 2009, where access could be gained. This involved recording the make and model of the appliances and, where possible, the gas type and charge.

In the calculation of the fugitive emissions only those resulting from the operation of the air conditioning and refrigeration equipment was included. Emissions associated with installation and disposal were not. Where gas type and charge were not known, typical values for the appliance type (e.g. domestic or commercial unit) were used. Emissions were calculated following a screening method.[8]

In total, there were over **17.6 tCO_2eq** (17,643 $kgCO_2eq$) of fugitive emissions from air conditioning and refrigerator equipment (**Table 4.1**). The majority of the fugitive emissions were due to the air conditioning systems used in the building, which were responsible for an estimated **16.8 tCO_2eq** (16,774 $kgCO_2eq$), with a less significant emissions release from refrigerators.

Fugitive Emissions type	Total GHG Emissions ($kgCO_2eq$)
Air Conditioning	16,774
Refrigerators	869
TOTAL	**17,643**

Table 4.1: Total GHG Emissions Generated by Air Conditioning and Refrigerator Equipment in 2008/09 Baseline Year.

It should be noted that there is a high level of uncertainty with the screening method used to estimate these emissions. Given that fugitive emissions at the Dumfries campus appear to be material (accounting for approximately 3% of the Scope 1 and 2 emissions) in subsequent footprint years, the simplified material balance method, as detailed by Defra/DECC (2009) should be utilised.

5 Leased Property – Workshop Space

The College offers opportunities for professional development related to the improvement of domestic properties, such as kitchen and bathroom suites. This takes place in partnership with the Dumfries and Galloway Housing Partnership (DGHP), giving those that attend the training the opportunity to work on the refurbishment of DGHP property.

During the baseline year, Dagcol ended the lease on one property for this purpose and signed a new lease for an alternative workspace. From September to December 2008, the College hosted training at Solway House on the Crichton Campus, which is owned by the Crichton Development Company. This lease ended on December 2008 and a new private lease was signed to host the workshops at a property on Edinburgh Road, Dumfries. A six year lease has been agreed between Dagcol and the building's owner, running from December 2008 to December 2014.

For the purposes of this energy audit, only the Edinburgh Road property is included within the assessment boundary. This is because it is the building presently leased by

[8] See Appendix C for the data collected using this method. See Annex 8 in Defra/DECC (2009) for further information on the methods used to estimate fugitive emissions.

Dagcol, where the lease extends throughout the 5 year action plan period. The building is used intermittently by the College, where occupancy varies within and between years in response to demand for training. In relation to utilities, Dagcol is responsible for the total invoice charges for electricity, gas and water.

5.1 Energy emissions

Energy consumption data (electricity and gas) for the Edinburgh Road building has been taken from invoices for the period 15 December 2008 to 31 July 2009 (the period for which the building was leased during the baseline year). Data is not available for water consumption at the premises. **Table 5.1** shows the total consumption, spend and GHG emissions for this period.

Energy type	Consumption (kWh)	Annual Cost incl VAT (£)	Total GHG Emissions ($kgCO_2eq$)
Gas	10,766	914.49	1,981
Electricity	6,109	1513.89	3,324
TOTAL		2428.38	5,305

Table 5.1: Total Energy Consumption, Cost and GHG Emissions for Edinburgh Road Workshop Space for the 2008/09 Baseline Year

Gas consumption totalled **10766 kWh** at a cost of **£914.49**, and with associated emissions of **1981 $kgCO_2eq$**. Electricity consumption totalled **6109 kWh** at a cost of **£1513.89**, and with associated emissions of **3,324 $kgCO_2eq$**. Of the total electricity emissions, **3069 $kgCO_2eq$** arise from generation of the consumed electricity and **255 $kgCO_2eq$** are the result of line losses during electricity transmission. In total, **5,305 $kgCO_2eq$** (5.3 tCO_2eq) were emitted as a result of energy consumption at the Edinburgh Road building.

It is noted that the energy consumption, costs and emissions are for a 7.5 month period and as such consumption in future assessment years is expected to be higher (under BAU). In this case, the data have not been extrapolated to an estimate for the full baseline year due to the intermittent occupancy of the building, which will exert a strong influence on energy consumption.

6 Energy-related Supply Chain Emissions

Supply chain emissions related to energy consumption are within the boundaries of the Dagcol carbon footprint assessment. This is in line with advice provided to signatories of the UCCCfS regarding inclusion of Scope 3 emission sources (EAUC, 2009).

Scope 3 GHG emissions are indirect emissions related to the upstream and downstream supply chains that are not classed as Scope 1 and 2 GHG emissions – that is emissions that occur as a consequence of the activities of an organisation, but physically occur at sources not owned or controlled by the organisation and are not associated with purchased energy.

In relation to energy consumption, Scope 3 emissions are those associated with the supply and distribution of energy products – for example emissions arising from extraction, processing and transportation of fossil fuels. These emissions are estimated from expenditure (not including CCL or VAT) and emissions factors derived from Environmental Input-Output (EIO) models. It should be noted that these EIO derived emissions factors are based on broad categories and represent a wide range of possible production methods. Two sets of EIO emissions factors have been utilised here. Firstly, the widely available supply chain emissions factors as provided in annex 13 of Defra/DECC (2009). These factors were calculated by the Centre for Sustainability Accounting (CenSA - www.censa.org.uk) and are based on 2004 basic prices. Secondly, the more up to date supply chain emissions factors based on 2007 basic prices as calculated by Small World Consulting (SWC - www.smallworldconsulting.co.uk).

For natural gas use, the supply chain emission factor includes emissions due to the production and distribution of the fuel (**Table 6.1**). Therefore, the supply chain emissions (Scope 3) are added to the direct emissions arising from burning the fuel (Scope 1) to provide an estimate of total emissions due to gas use. Note the gas use for the Dumfries building is estimated (see Section 3.3), where the estimated spend assumes a unit price of £0.02031/kWh.

	Consumption	Spend	Scope 1		Scope 3		Total GHG Emissions
	kWh	£	$kgCO_2eq/kWh$	$kgCO_2eq$	$kgCO_2eq/£$ (SWC - CenSA)	$kgCO_2eq$	$kgCO_2eq$
Dumfries	1,800,000	£ 36,558	0.18396	331,128	2.0429 - 3.3799	74,685 - 123,563	405,813 - 454,691
Edinburgh Rd	10,766	£ 617	0.18396	1,981	2.0429 - 3.3799	1,261 - 2,085	3,241 - 4,066

Table 6.1: Gas Consumption Scope Three Emissions for Dumfries Campus Building and Edinburgh Road Workshop

For electricity, the supply chain emission factor includes emissions due to the production and transport of the fuels used to generate the electricity (Scope 3), in addition to the emissions arising from the use of those fuels by the electricity producers (Scope 2). Therefore in this case, the calculated supply chain emissions provide an estimate of total emissions due to electricity use (Scope 2 + Scope 3). An estimate of the additional emissions due to production and transportation of the fuels (Scope 3) is derived by subtracting the estimated Scope 2 emissions for electricity (**Table 6.2**).

	Consumption	Spend	Scope 2		Scope 3		Total GHG Emissions
	kWh	£	$kgCO_2eq/kWh$	$kgCO_2eq$	$kgCO_2eq/£$ (SWC - CenSA)	$kgCO_2eq$	$kgCO_2eq$
Dumfries	1,469,215	£ 202,719	0.54418	799,517	8.1182 - 9.7919	1,645,723 - 1,985,005	2,445,241 - 2,784,522
Edinburgh Rd	6,109	£ 1,212	0.54418	3,324	8.1182 - 9.7919	9,841 - 11,869	13,165 - 15,194

Table 6.2: Electricity Consumption Scope Three Emissions for Dumfries Campus Building and Edinburgh Road Workshop

For the purposes of calculating the total footprint of Dagcol, the supply chain emissions are based on the EIO emission factors in 2007 basic prices as calculated by SWC. As a result of energy use at the Dumfries campus and its related buildings, **1,732 tCO_2eq** (1,731,510 $kgCO_2eq$) of GHGs were produced by energy supply chain emissions.

7 Recommendations

This section contains recommendations for areas where improvements could be made, resulting in both cost savings and reductions in GHG emissions.

7.1 Building Fabric and Heating

These recommendations have been taken from the building survey report conducted by Mark McKenna (see separate report).

Investigation of the margin of temperature increase required during winter time.

Closing of some, if not all, fire doors. Leaving doors open makes temperature control through zoning difficult. The following actions should be taken:

1. **review remote temperature settings to account for temperature overshoots**
2. **test zones 2/4/6 with temperatures 1-2°C lower.**

Thermostatic sensors – some out of place or not within area intended to be monitored.

1. **review of current zone allocations, possible sensor distribution**
2. **increase the number of sensors in each zone, particularly in unconventionally shaped space. The sensors should take the average temperature of each zone.**

As highlighted in **Figure 3.2** (**Section 3.4**), the electricity generated by EDF Energy and Scottish Power is carbon intensive, with almost half produced by coal combustion. A potential option would be to change electricity supplier, switching to a company that generated electricity from 100% renewable energy or has a high percentage of renewable in its fuel mix. The installation of on-site renewables for Dagcol to produce their own electricity, such as wind, biomass or solar thermal, could be a future option. However, this would require a feasibility study to be carried out to determine the renewable energy option most suited to the location of the campus building.

As indicated in the building survey, comments were made by office staff about heat build-up during the summer months due to solar radiance. Though blinds are used to reduce the build-up, there is still a negative effect on the working environment. A potential additional measure could be the use of solar control film, which are applied to windows retrospectively and reduces the level of sunlight entering the building.

It is recommended that consideration be given to changing Dagcol's electricity supplier to a company that has a high percentage of renewable energy in their fuel mix.

Consider installing onsite renewables with a feasibility study being carried out to determine the best option for the Dumfries campus.

Investigate the feasibility of using solar film on windows to reduce solar radiance.

7.2 Energy Management

In the calculation of the gas consumption using degree days it was highlighted that gas consumption measurements were not taken regularly. This may have had an effect on the estimated gas consumption. This could be improved by using the campus Building Management System to measure the data required for the calculation of degree days.

It is recommended that the campus' Building Management System is programmed to generate accurate estimates of the building's true baseline temperature in subsequent footprint years.

Continue the utilisation of degree days and accumulative energy management tools to monitor heating demand and gas usage.

7.3 Lighting Levels

In the Dumfries campus building it was observed that the lighting levels seem to be very high, with a large quantity of double-bulb fluorescent light fittings throughout the building. It may be the case that there are more lights situated throughout the building than is required. **Table 7.1** shows the recommended internal lighting levels for particular rooms and work areas throughout a working building. The lighting levels for the various room types throughout the campus building should be measured to determine how they compare with these recommended levels. This will indicate whether changes could be made to reduce electricity consumption through lighting.

Comparative Light Levels	**LUX[9]**
Worktop near window	3000
Precision task lighting	1,000*
Drawing boards	750*
General Reading Areas	300*
Entrance Halls	150*
Corridors & Storage	100*
Full moon on clear night	1

Table 7.1: Lux internal lighting levels
* Recommended lighting levels

Unlike higher wattage fluorescent bulbs, the T5 variety does not produce high levels of flicker, which can cause headaches. As a result, it may be possible to remove a single bulb from each double fitting throughout the building. As highlighted in **Table 7.2**, this has the potential to reduce electricity consumption[10].

[9] LUX = The unit of illuminance measured in lumens per m^2 (lm/m^2)
[10] This is based on a scenario with all fluorescent bulbs being left for 8.5 hours per day, representing core class and working hours. In this scenario, there are a total of 179 term time days, with all bulbs being switched on during core hours. In relation to non-term time days, these total 70 days, with additional assumptions that only bulbs in offices and open areas will be in use. It is assumed that 60% of bulbs are situated in classrooms, with 20% in open areas (e.g. corridors) and the remaining 20% in offices and staff work areas.

Total Bulbs	Power Consumption (W)	Total Power Consumption (kWh/day)	Total Power Consumption (kWh/term time)	Total Power Consumption (kWh/non-term time)	Total Power Consumption (kWh/year)
3,824	28	910	162,910	25,483	188,393
1,912	28	455	81,455	12,742	94,197

Table 7.2: Illustration of Energy Consumption Savings Resulted from the Removal of 50% of T5 Fluorescent in the Dumfries Campus Building

Halving the number of T5 fluorescent bulbs has the potential to deliver savings of **94,000 kWh** of electricity, which is equivalent to approximately **£10,500** and GHG emissions of **51 tCO_2eq**

It is recommended that the lighting levels of the main campus building are reviewed and that they are measured and compared with those of highlighted in Table 7.1.

Investigate the feasibility of removing half of all T5 bulbs in double fittings (or equivalent action) by selecting test areas and noting comments from staff and students on the effect this has on their ability to work and study.

7.4 Behavioural Change

The Dumfries Campus has made a number of policy choices regarding procurement of energy efficient products and lighting, which means that positive steps have been taken to reduce electricity consumption. However, further savings could be made through 'behavioural changes' that can be made by staff and students, which have no cost and would require raising awareness of energy use.

As highlighted in Section 5, a number of electrical appliances are either not being shut down or left on standby by both staff and students. It is recognised that it is not feasible to shutdown equipment during class and office hours, however by properly shutting down and switching off these items there is the potential to make a number of savings.

During visits to the campus it has been observed that a number of students use the disabled access doors, rather than the revolving doors. This not only uses energy but also causes heat loss from the building due to the prolonged time that the doors remain open to allow access. It is recognised that during peak movement times, such as before and after classes and during lunch times, it is more feasible to allow all students to have access to this facility. However, during quiet times there is relatively free access to the revolving doors. This could be a good opportunity for participation by both staff and student, with the possibility of including the art department in producing a sign or poster to promote this action.

It is recommended that an awareness campaign encompassing and involving all staff and students should be carried out to encourage the complete shutdown of computers and the switch off of monitors after use, as well as the switching off of printers and Promethean system units at the end of the day. The relative energy costs of 'power-up' versus overnight standby energy usage should be checked prior to implementation.

Highlight the issue of the disabled door use by staff and students. Promote the use of the revolving doors instead of the electric doors, with the potential to involve the College art department.

7.5 Computer Desktop Shutdown and Switch Off

The campus has been proactive in ensuring that their networked desktop computers are being fully shutdown at the end of the day. A software product is used, which has a scheduled shutdown time of 10pm at the end of each day. This reduces the power consumption by any desktops that have been left on. This could be further enhanced by having more bespoke software and defining computer clusters relating to the times that they are out of use, for example:

- Classrooms and IT suites– 6pm
- Staff offices – 7pm
- Library area – 7.30pm (Mon-Thurs), 5pm (Fri)

When examining a situation (scenario 1) when all College PCs are not shutdown until 10pm after core hours end at 4.30pm, this is likely to consume over **1500 kWh** electricity. This results in costs of almost **£170** per year and GHG emissions of **c. 0.8 tCO_2eq** (**Table 7.3**). However, if shutdown clusters are applied, there are indications that potential savings could be made by staggering the shutdown of College PCs. As denoted in **Table 7.4**, this would reduce energy consumption and emissions by around two thirds, decreasing emissions by **c. 0.5 tCO_2eq**.

While this is a marginal saving when compared to total electricity usage, this scenario considers only desktop PCs (not monitors and peripheral equipment) during term time week days, and total potential savings are likely higher.

Appliance type	Number of appliances	Energy use per total term days (kWh)	Spend/total term days (£)	Spend/month (£)	GHG emissions/total term days (kg CO_2eq)
All PC Desktops	665	1514.21	168.11	14.01	824.00

Table 7.3: Scenario 1 – All PCs left on and shutdown at 10pm

Appliance type	Number of appliances	Energy use per total term days (kWh)	Spend/total term days (£)	Spend/month (£)	GHG emissions/total non-term days (kg CO_2eq/yr)
Classroom PCs	363	225.42	25.03	2.09	122.67
Office PCs	181	187.34	20.8	1.73	101.94
Library PCs	121	150.28	16.68	1.39	81.78
TOTAL	**665**	**563.04**	**62.51**	**5.21**	**306.39**

Table 7.4: Scenario 2 – Staggered PC shutdown

As highlighted previously, both desktop PCs and Apple MACs consume power when shutdown but are still switched on at the power source. Due to the large number of plugs and accessibility issues in classrooms and offices it may not be feasible for all desktops to be switched off at the plug by an individual. However, it may be possible for either the last persons in a classroom or individual staff members using a desktop computer, to switch their computers off at the plug. Raising awareness for energy conservation among the staff and students will have additional benefits if it encourages good practice habits to form and be translated from the work place to home. Another additional consideration could be to implement electrical zoning in particular areas of the building, for example shutting off the electricity to offices outside of working hours or IT suites outside class hours.

It is recommended that bespoke software for the purposes of computer shutdown should be investigated, along with the identification of potential computer clusters at the Dumfries campus.

Raise awareness to staff and students of switching off the power supply to electrical equipment at the end of the working/teaching day.

Investigate the potential to create electrical zones to switch off equipment en-mass outside working/teaching hours.

7.6 Reprographics Photocopiers

The reprographics department of Dagcol uses two large photocopiers, which, despite being Energy Star rated, consume a significant quantity of electricity. These are both constantly switched on, even when not in use and left on standby overnight. Over the course of a term, the combined power consumption of the photocopiers outside College occupancy hours comes to approximately **2,100kWh**. This is the equivalent to electricity costs of almost **£250** during the academic year and would result in the emission of over **1000 kg CO_2eq** of GHGs.

Appliance type	Number of appliances	Electricity use per total term days (kWh)	Spend/total term days (£)	Spend/month (£)	GHG emissions/total term days (kg CO_2eq)
Photocopier	2	2073.24	242.52	20.21	1,084.55

Table 7.5: Reprographic Photocopier Power Consumption during Term Time

When discussing this issue with reprographics staff, it was highlighted that the warm up time from off for the photocopiers is relatively short (360 seconds for the Gestetner 10512 and 300 seconds for the Gestetner DSc 460 Aficio[11]). Due to this, it would be feasible to test switching off the photocopiers overnight to assess what effect it would have on the efficiency and production of the photocopying process.

It is recommended that switching the photocopiers off overnight should be tested and an investigation be carried out of the impact this has on the production of the photocopiers over the working day.

[11] Based on 23°C room temperature.

8 Conclusion

This draft report represents the energy portion of the baseline carbon footprint for the Dumfries Campus of Dumfries and Galloway College. It has been carried out in fulfilment of the Universities and College Climate Change Commitment for Scotland.

An audit of the energy data held by the campus has highlighted several data gaps. The most notable of these is for gas consumption. This is due to the College not being charged for the gas that they use for heating since the campus opened in 2008. There are also missing invoices for water consumption. A full record of invoices is available for electricity use, with almost 1.5 million kWh being used during used in the baseline year, with approximately 800,000 kg CO_2eq of GHG being emitted. It is estimated the gas consumption, using degree days, is c.1,800,000 kWh, with resulting GHG emissions of **331,128 kg CO_2eq.** However, there are indications that electricity use may be influenced by the work of contractors in and out of the building before its completion. In total, including the leased Edinburgh Road property, over **1,100,000 kg CO_2eq** of GHG emission were generated.

The campus building is only one year old, being completed in 2008 and meets 2007 Building Standards; therefore there are no major improvements that need to be recommended. Similar could be said for the lighting, with low energy bulbs and PIR systems implemented throughout the building. Electrical equipment is also energy efficient in the majority of cases, due to the College's green procurement policy. There are opportunities to reduce current levels of electricity, specifically through the promotion of behavioural change and switching off IT appliances at the plug at the end of the day. These are basic recommendations and will be followed up during the options generation workshop later in the year.

9 References

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Appendix A – Dumfries Campus Bulb Types

Light Fitting Type	Bulb Type	Bulbs per Fitting	Total Bulbs
C	150W Metal Halide	1	49
G	26W Compact Fluorescent	2	132
I	18W Compact Fluorescent	1	16
L	26W Compact Fluorescent	2	12
M	55W Compact ‘U’ Tube Fluorescent	6	6
R	28W 2D Fluorescent	1	42
T1	150W Metal Halide	1	89
T5	F28W Fluorescent	2	3824
V	38W 2D Fluorescent	1	89
W	55W Circular T5	1	15
Z	10W Compact Fluorescent	1	36

Appendix B – Degree Days Calculation

As gas consumption data were not available for the 2008/09 baseline year, the quantity of gas consumed was estimated from degree day data for the baseline year and the observed correlation between gas consumption and degree days over the measurement period from 27/07/09 to 15/12/09 (covering both summer and winter months).

NOTE: Using the Building Management System will enable a more accurate measurement of degree days and associated energy consumption than the estimate presented here.

Degree days relate to the intensity and duration of cold weather, where the number of degree days is essentially the summation over time of the temperature difference between the buildings base temperature and the external temperature. The colder the outside temperature over a defined time period, the greater the degree day value.

The base temperature is the external temperature limit above which a building's heating system does not need to operate to maintain the indoor temperature. This will vary from building to building and will depend on their energy efficiency; however the UK average is 15.5°C. When the external temperature is equal to or greater than the base temperature, degree days are zero.

Gas meter readings were taken on an approximately weekly basis over the measurement period by Diston Dryburgh (Estates Officer – Dagcol), where the time between reading ranged from 4 to 20 days. Irregular readings may affect the quality of the data, and therefore the accuracy of the estimated gas consumption for the baseline year.

Meter readings were converted from gas consumption in units of volume (m^3) to energy (kWh) using Equation 1 (from new gas supplier, Eon):

$$E\ (\text{kWh}) = G * C * \frac{1000}{3600} * 1.02264 \qquad \textbf{[Eq. 1]}$$

Where G is the volume (m^3) of gas consumed between readings (reading B – reading A), C is the gross calorific value of the gas[12] (value used here is 39.64219 MJ/m^3, the average of the reported CV on the two available invoices), the factor (1000/3600) is the conversion from MJ to kWh, and the factor of 1.02264 is a volume correction factor (to account for the difference between the actual temperature and pressure of the gas and standard temperature and pressure). The estimated gas consumption in kWh over the measurement period is given in **Table A**.

Daily degree day data were obtained from the Environmental Change Institute of Oxford University[13], where this data set utilises temperature data recorded at the Eskdalemuir meteorological station in Dumfries and Galloway. For any future degree day calculations, data from this station should be used to ensure consistency. The daily degree day data were summed to obtain the total degree days corresponding to each gas consumption period.

[12] The calorific value (CV) is the measure of the quantity of energy released when a certain amount of fuel is combusted. In the UK, the gross CV of natural gas ranges from 37.5 – 43.0 (MJ/m^3). Customers' bills are based on daily CV averages.
[13] Data available from – http://www,eci.ox.ac.uk/research.energy/degreedays.php

As the base temperature of the main campus building was unknown, we examined the correlation between gas consumption and degree days for several base temperatures ranging from 10.5°C to 15.5°C. The best correlation was observed for a base temperature of 12.5°C (See **Table B**).

Gas consumption for the baseline year was then estimated from the observed correlation between degree days and gas consumption for the measurement period, and the total number of degree days for the baseline year. The results of this analysis are shown for a building base temperature of 12.5±1°C in **Table B** below. These results indicate a gas consumption on the order of 1,800,000 kWh gas per year (to 2 significant figures).

Meter Reading Date	Gas Meter Readings (m^3)	Gas Consumption (m^3)	Gas Consumption (kWh)
27/7/09	187,528	-	-
31/7/09	187,677	149	1,678
7/8/09	187,835	158	1,779
14/8/09	188,050	215	2,421
21/8/09	188,390	340	3,829
28/8/09	188,691	301	3,390
4/9/09	189,072	381	4,290
18/9/09	191,486	2,414	27,184
25/9/09	192,424	938	10,563
5/10/09	193,479	1,055	11,880
9/10/09	195,614	2,135	24,042
16/10/09	197,589	1,975	22,241
23/10/09	199,768	2,179	24,538
6/11/09	204,589	4,821	54,289
13/11/09	208,755	4,166	46,913
3/12/09	221,264	12,509	140,864
15/12/09	230,132	8,868	99,863

Table A: Gas Consumption Data during the Recording Period 27 July 2009 to 15 December 2009

Building Base T	Measurement Period		Baseline Year	
C	m	R^2	degree days	kWh
11.5	1015.3	0.9741	1753.9	1,780,745
12.5	869.0	0.9783	2035.6	1,768,874
13.5	748.2	0.9628	2338.0	1,749,234

Table B: Correlations between degree days and gas consumption (gas consumption = m*degree days) for the measurement period, and estimated gas consumption for the baseline year

Appendix C – Air Conditioning and Refrigeration Fugitive Emissions

Total GHG Emission Generated by Air Conditioning Units at Dumfries Campus

Type of Air Conditioner	Serial Number	Number of Units	x	Equipment Charge Capacity kg	x	Time Used During Reporting Period (year) Year Number	x	Annual Leak Rate	x	Refrigerant type	Global Warming Potential	=	Total GHG Emissions $kgCO_2eq$
City Multi	72W00266	1	x	11.8	x	1	x	8.50%	x	r410a	1725	=	**1,730.18**
City Multi	72W00279	1	x	11.8	x	1	x	8.50%	x	r410a	1725	=	**1,730.18**
City Multi	7YW00004	1	x	13	x	1	x	8.50%	x	r410a	1725	=	**1,906.13**
City Multi	71W00237	1	x	11.8	x	1	x	8.50%	x	r410a	1725	=	**1,730.18**
Mr Slim	78U02153	1	x	5	x	1	x	8.50%	x	r410a	1725	=	**733.13**
Mr Slim	78U02194	1	x	5	x	1	x	8.50%	x	r410a	1725	=	**733.13**
Mr Slim	78U02248	1	x	5	x	1	x	8.50%	x	r410a	1725	=	**733.13**
Mr Slim	78U02219	1	x	5	x	1	x	8.50%	x	r410a	1725	=	**733.13**
City Multi	7YW00005	1	x	13	x	1	x	8.50%	x	r410a	1725	=	**1,906.13**
City Multi	71W00228	1	x	13	x	1	x	8.50%	x	r410a	1725	=	**1,906.13**
Mr Slim	78U02246	1	x	5	x	1	x	8.50%	x	r410a	1725	=	**733.13**
Mr Slim	78U02267	1	x	5	x	1	x	8.50%	x	r410a	1725	=	**733.13**
Mr Slim	78U02231	1	x	5	x	1	x	8.50%	x	r410a	1725	=	**733.13**
Mr Slim	78U02456	1	x	5	x	1	x	8.50%	x	r410a	1725	=	**733.13**
TOTAL		**14**											**16,773.90**

Total GHG Emissions Generated by Refrigerators at Dumfries Campus

Type of Refrigerator	Number of Units		Equipment Charge Capacity (kg)				Time Used During Reporting Period (year)		Annual Leak Rate		Refridgerant Global Warming Potential (GWP)				Total GHG Emissions ($kgCO_2eq$)		
		x	Lower	Upper	Specific	x		x		x	Lower	Upper	Specific	=	Lower	Upper	Specific
BEKO Fridge	11	x	-	-	0.0017	x	1	x	0.30%	x	-	-	0.001	=	-	-	0.00000006
Fujifilm Professional Staycold	1	x	-	-	0.25	x	1	x	2.00%	x	-	-	1300	=	-	-	6.50
Norcool Super 8	1	x	-	-	0.145	x	1	x	2.00%	x	-	-	1300	=	-	-	3.77
BC-42 (Wine Cooler)	1	x	0.2	6	-	x	1	x	2.00%	x	0.001	1300	-	=	0.0000040	156.00	-
Matsui Fridge	1	x	-	-	0.022	x	1	x	2.00%	x	-	-	0.001	=	-	-	0.00000044
Daewoo Fridge/Freezer	1	x	0.05	0.5	-	x	1	x	0.30%	x	0.001	1300	-	=	0.00000015	1.95	-
Catering Chillers	3	x	0.2	6	-	x	1	x	2.00%	x	0.001	1300	-	=	0.00001200	468.00	-
Soft Drinks Vending Machines	7	x	0.2	6	-	x	1	x	2.00%	x	0.001	1300	-	=	0.00002800	1092.00	-
TOTAL	**26**													=	**0.00000415**	**1717.95**	**10.27**

Appendix D – Emission Factor Summary

In the utilisation of emissions factors to convert the various transport activities in the scope of the Dagcol footprint, all of which were obtained from the Department of Environment, Fisheries and Rural Affairs (Defra). Below, the emission factor used for each activity in the footprint will be highlighted, along with its source and the reasoning behind its use.

Activity	**Emission factor**	**Source**	**Reasoning behind use**
Space and Water Heating	Natural Gas – 0.18396 kg CO_2eq/kWh	2009 Standard emissions factors taken from DEFRA/DECC (2009) Guidelines to Defra/DECC's GHG conversion factors for company reporting	The Defra standard emission factors for energy consumption was used as they are the benchmark figures published by the Government. It must be noted however, that this factor includes the emissions caused by burning the fuel, it does not include the processes utilised in the drilling, removal or transport of the fuel.
Fugitive Emissions	R410a – 1725 R600a – 0.001 R134a - 1300	2009 Standard emissions factors taken from DEFRA/DECC (2009) Guidelines to Defra/DECC's GHG conversion factors for company reporting	The Defra standard emission factors for fugitive emissions was used as they are the benchmark figures published by the Government. It should be noted that there are a number of uncertainties connected with these emissions factors.
Purchased Electricity	Electricity Generated – 0.50238 kg CO_2eq/kWh Electricity Losses – 0.04180 kg CO_2eq/kWh Electricity Consumed – 0.54418 kg CO_2eq/kWh	2009 Standard emissions factors taken from DEFRA/DECC (2009) Guidelines to Defra/DECC's GHG conversion factors for company reporting	The Defra standard emission factors for energy consumption was used as they are the benchmark figures published by the Government. It must be noted however, that this factor includes the emissions caused by burning the fuel, it does not include the processes utilised in the drilling, removal or transport of the fuel.

Supply Chain Emissions	Mains Gas – 3.38 $kgCO_2eq/£$ Mains Electricity – 9.79 $kgCO_2eq/£$	2009 Standard emissions factors taken from DEFRA/DECC (2009) Guidelines to Defra/DECC's GHG conversion factors for company reporting	[a]These emission factors relate to the supply and distribution of energy products for general consumption, and take into account emissions relating to the extraction and processing of energy carriers. Except in the case of electricity, they do not include emissions relating to you company's use of the energy. In the case of electricity, these factors include the emissions relating to the production of the fuels used to generate electricity.[14] [b] These emissions related to the activities of the industries engaged in the extraction of energy carriers.[15]
Supply Chain Emission	Mains Gas – 2.0429 $kgCO_2eq/£$ Mains Electricity – 8.1182 $kgCO_2eq/£$ Burning Oil -		

14 Defra/Department of Energy and Climate Change (2009) 2009 Guidelines to Defra/DECC's GHG Conversion Factors for Company Reporting v2.0 (London; Defra, DECC). Full text available from: http://www.defra.gov.uk/environment/business/reporting/pdf/20090928-guidelines-ghg-conversion-factors.pdf

15 Ibid