**Cardiff University Carbon Audit 2021**

**28th February 2022**

Produced by Prof Mike Bruford, using data collected by interns Weronika Tadrak (Scopes 1, 2, 3), Nuo Jin and Tasarla Deadman (Travel).

This summary report should be read in conjunction with the [Climate Emergency Summary Report 2021]

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**Background:**
Three student interns have analysed our carbon emissions for the period 2020-2021, building on our previous analysis of 2017-2019, including Scopes 1, 2 and 3. The data produced will be relevant for reporting both internally on our 2020 emissions, and to Welsh government on our institutional Carbon emissions. It aligns to our Climate Emergency Declaration of 2019 for carbon net zero by 2030. Annual emissions analysis and reporting are needed to assess the impact of carbon mitigation measures we implement. Weronika Tadrak worked on all aspects of emissions accounting, liaising with appropriate staff. What follows summarises her work, which went through several iterations and sense checks during its production, but where significant issues remain in terms of data quality and reliability.

**Scope 1 emissions**
Use of gas was estimated from invoices provided by Corona Energy, using standard DEFRA conversion factors and following Welsh Government guidance. Most readings are classified as ''E'' (estimate) and readings underwent conversion (from m³ to kWh, then to kgCO2e and tCo2e). The data presented have a 2% error margin as per Welsh Gov Guidance.

**Figure 1**: Gas consumption GHG Emissions 2019/21

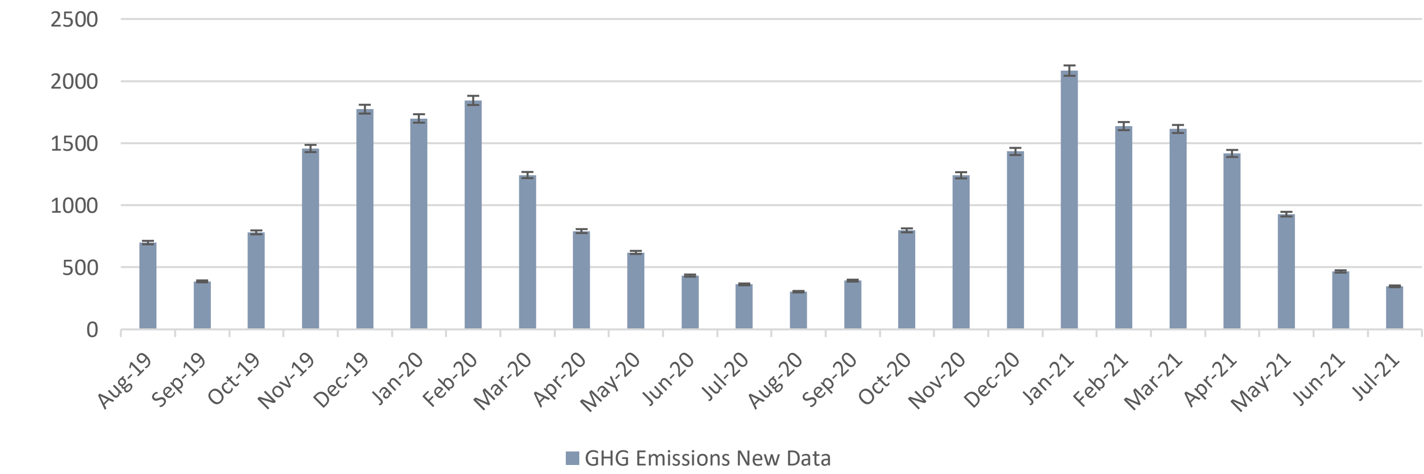


**Figure 1** represents the changes in carbon emissions from buildings owned by Cardiff University from August 2019 to July 2021. Cyclic seasonal variation in emissions can be observed as gas use is linked to outside temperature. It was anticipated that the emissions from gas consumed might be significantly lower as the pandemic hit and University buildings were not in use. However, as the profile in **Figure 1** shows there was actually little difference, most likely because heating regimes were not adjusted. When comparing Corona consumption invoices with those recorded, some disparities in the data were noted. Percentage comparison shows that the average error is 3.7%, 5% and 0.3% for 2019, 2020 and 2021 respectively. The data from Finance and from the invoices, however, represent information gathered from different numbers of meters (invoices = 270 meters, Finance = 166 meters). In 2019 the gas supplier changed, and initially Corona energy had no experience with Cardiff University gas consumption, leading to disparities between readings and actual gas consumption, later requiring readjustment.

**Fig 2:** Corrected GHG Emissions from gas using Cardiff Uni Gas and Corona Invoices 2019/21

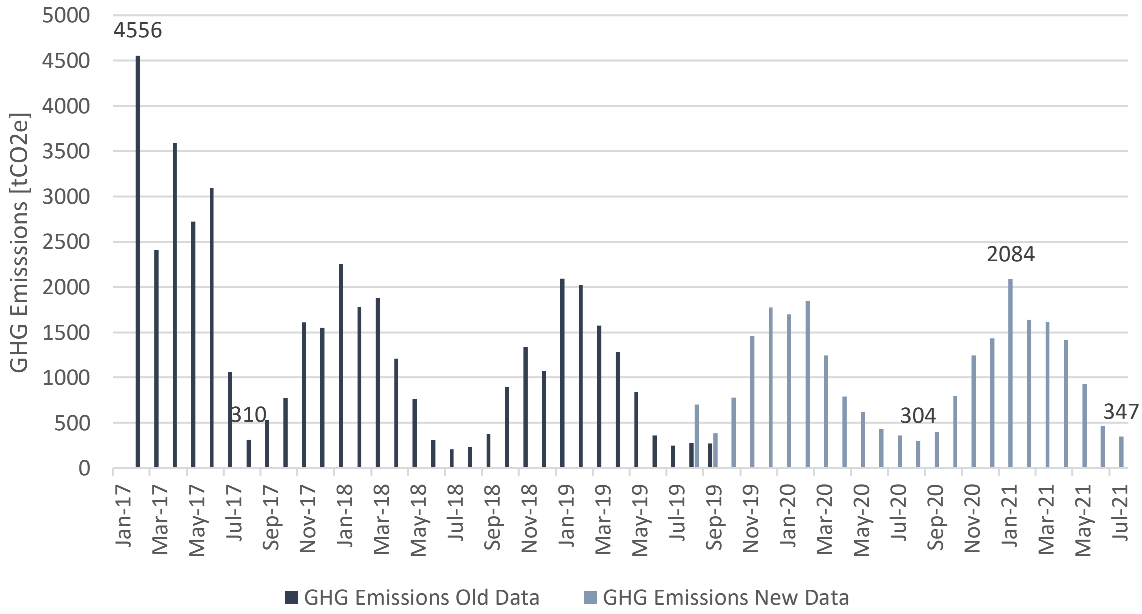



**Figure 2** shows the cyclic variation in carbon emissions from February 2017 to July 2021 with the most error prone months from the old dataset omitted. The cyclical seasonal pattern can once again be observed. 2020 has the lowest peak carbon emissions. As gas use varies depending on temperature, it is important to take into consideration the monthly variation in temperature profiles. For example, in 19/20 the emissions values in the winter are lower than in the winter of 2020/21. However, winter 19/20 was much warmer than winter 20/21. Average gas emissions from University buildings [tCo2e] averaged 12,406 between 2019 and 2021, with the 2020 data total being 11,754. Considering the error margins in the data, it can be concluded that **gas usage in University buildings has remained very similar over the last 5 years**. For fleet consumption, we currently have a disparity in estimated emissions between 2017 and 2019 and 2019 and 2021. This is because earlier estimates were based on annual MOT mileage readings using conversion factors (100 vehicles), whereas later years were based on fuel invoices (200 vehicles). MOT data suggest fleet mileage per 100 vehicles decreased from c36,000 to c29,000 between 2017 and 2020, whereas invoice data imply a

much higher value. Assuming the MOT data are accurate, for a fleet of 200 vehicles between 30 and 90 tCO2e per annum can be expected, depending on fuel efficiency, the proportion of different types of fuel used and the conversion factor used, a relatively modest proportion of our Scope 1 emissions.

**Scope 2 emissions**

Electricity data were gathered from invoices and confirmed with data processed by Finance. The data was collected separately from 181 meters either as hourly or non-hourly readings. Figure 3. Shows the monthly variation during the period. It can be observed that the electricity use seems to be more uniform in 2021, while use fluctuated more significantly in 2019 and 2020, with lowest values observed during spring and summer months of 2020, most likely due to the pandemic and general lockdown.

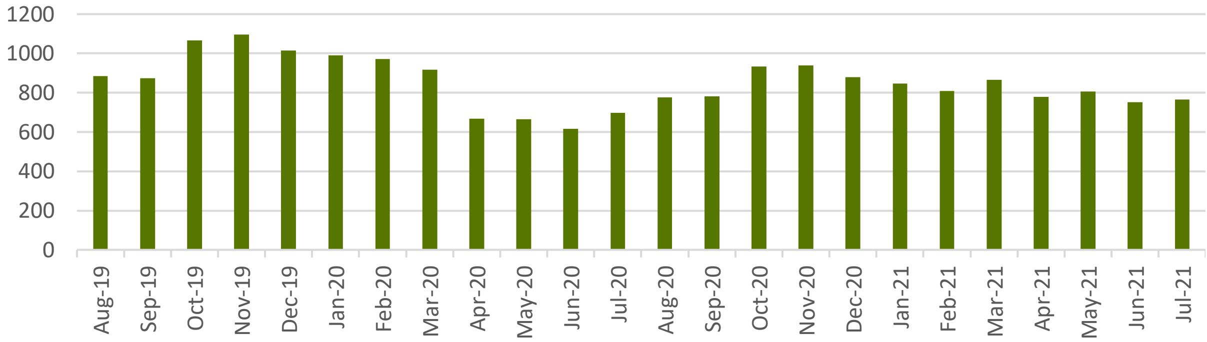
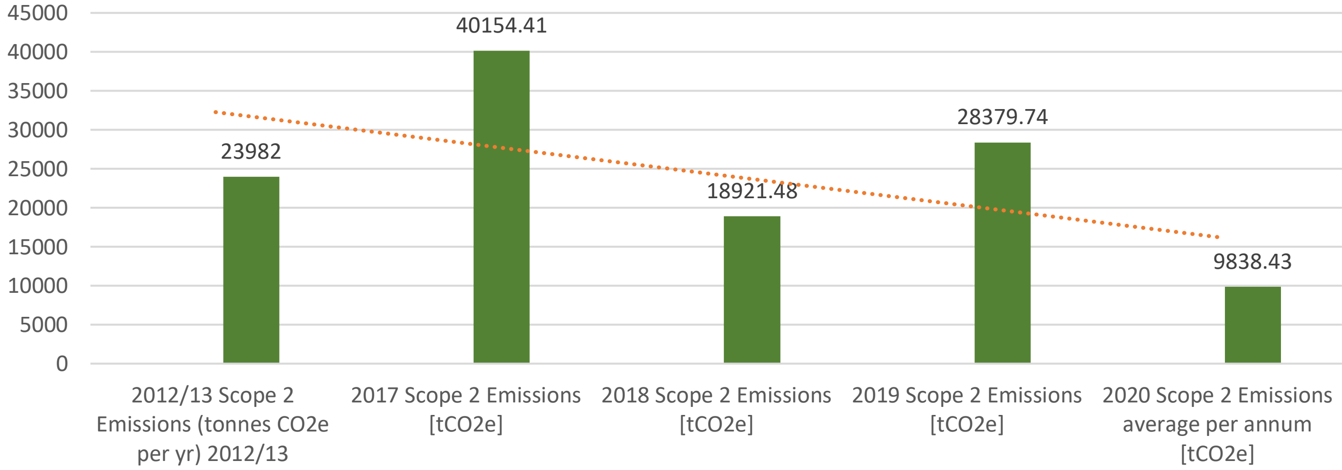



**Fig 3.** Monthly Variation in GHG emissions from Electricity 2019/21

Values are generally decreasing as time passes, but again slight seasonal fluctuations are evident, with increased emissions during the winter months. Despite the values fluctuating it has been noted that the ratio of electricity use between residential and non-residential sector remained consistent with percentage distribution at c83% for non-residential buildings.

**Fig 4.** Annual Variation in GHG emissions from used Electricity 2017-2021



As with the gas estimates, disparities were found between old and new data (number of meters recorded) and between years. For example, some meter reading data are lacking for 2018 (see **Figure 4**) leading to an erroneously low estimate for that year. Also, disparities in estimates were generated as a result of changing suppliers. The first dataset (2019-2021) was based on electricity meter readings checked with the data collected by Finance in monthly increments. The second, older data set (2017-2020) was processed with annual granularity for the purpose of previous Carbon Modelling. The values represented show that there is a significant decrease in energy use from 2017 to 2020. However, the data from 2019/21 seems to contain data only from 181 meters, while the entirety of the ''Cardiff Uni Elec Jan 2017 to May 2020'' seems to consider about 365 meters but readings are not consistently taken every month. The year 2018 in particular seems to have missing readings from tens of meters. Data set for 2020 is more reliable.

**Scope 3 emissions (non-travel)**

*Water and Sewage*

Water consumption in cubic meters was collected from meter readings across the University campus. Emissions from water and sewage were estimated based on ''Cost and volume'' files provided by Cardiff University. Total GHG emissions from water and sewage resulted in 288 tCO2e from August 2019 to August 2021: 100 tCO2e from water consumption and 188 tCO2 from water treatment. The baseline emission for water consumption and treatment was 121 $tCO_2e$ pa compared with 577 $tCO_2e$ in 2012/13. **Figure 5** shows highest emissions can be observed in October 2019 and March 2020, while the lowest in July 2021.

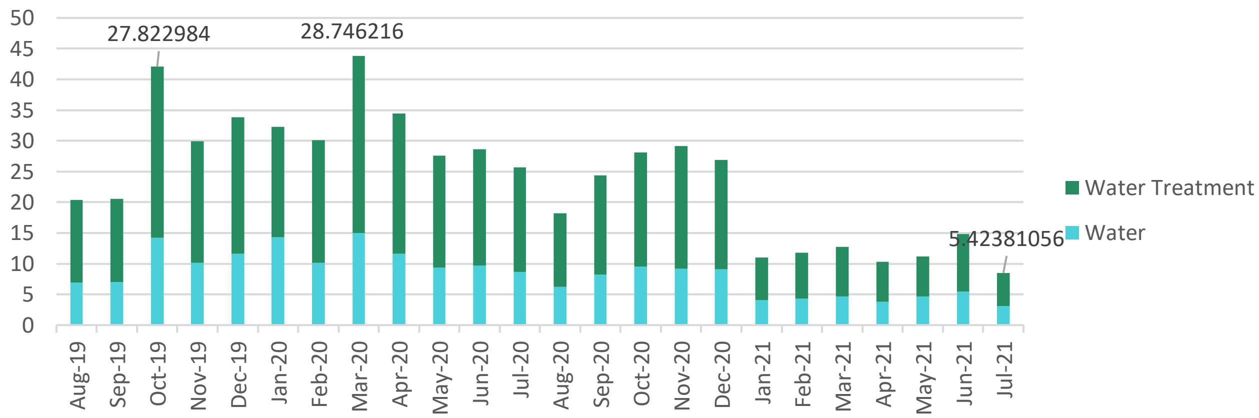



**Fig 5.** Monthly GHG emissions from water and water treatment 2019-21

*Procurement*

As with last year, estimates of emissions arising from used products were calculated via the Higher Education Supply-Chain Emission Tool (HESCET). In 2009, 75 DEFRA categories were established and were used for last year's emissions estimates. However, in 2021 the DEFRA factors were updated to adjust to changed methods of production, materials, and logistical methods of delivery. The new version of HESCET contains 311 categories, shifting the emphasis of categories from industrial to domestic. As seen in **Figure 6**, emissions from procurement varied greatly between months (lowest November 2019: 2.37 tCO2e, highest March 2021: 19183.44 tCO2e). There is a drop in procurement emissions in May and June

2020. Monthly emissions have been increasing from 2019 to 2021: a significant increase of 34% in the tCO2e values. Further analysis of emissions from different categories will help identify the parts of procurement contributing to the increase.

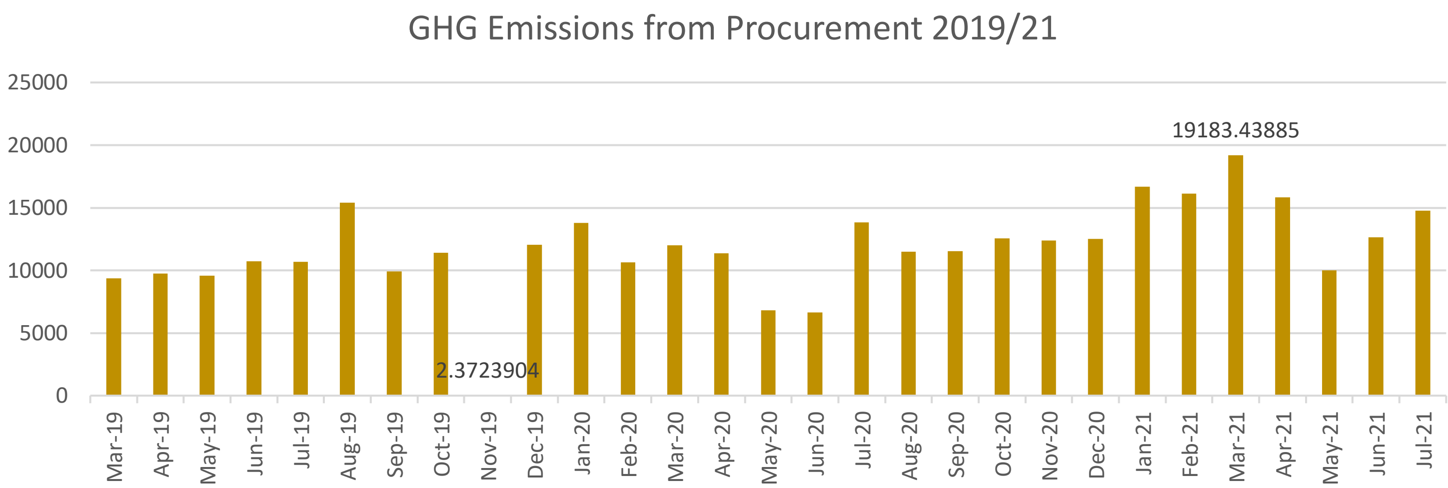



**Fig 6.** Monthly distribution of GHG emissions from procurement 2019-21

**Figure 7** shows an example, from 2020, of the breakdown of procurement-based emissions in 2020. It shows that Business Services, Medical and Precision Instruments, ICT and construction dominate the emissions, but this fluctuates substantially.

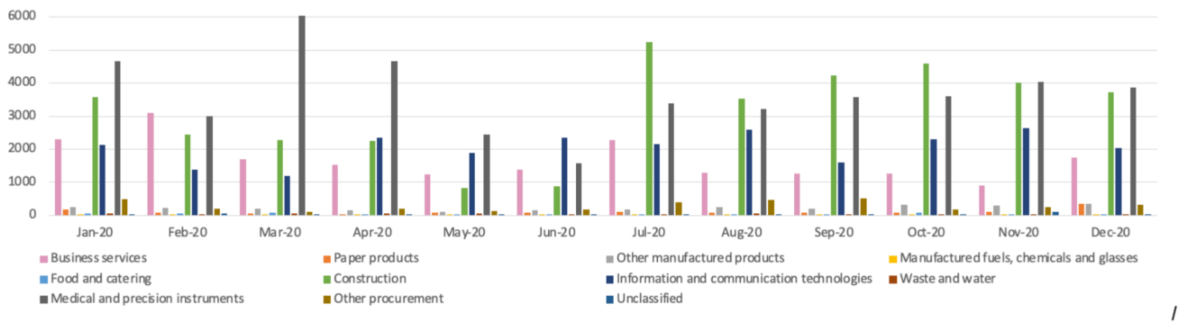



**Fig 7.** Monthly distribution of GHG emissions by category 2020

Through monthly analysis of GHG emissions from different categories, it can be observed that the HESCET tool estimated that Medical and precision instruments were the highest source in 2019 and 2021. It was expected that the data for 19/20 academic year would vary from a typical trend, due to the pandemic and resulting need to invest more in medical equipment. In 2019 the second highest GHG emitter was ICT, closely followed by construction. From July to December 2020, emissions from construction and services were the highest. As with last year, a high percentage of emissions originated from businesses services. However, as previously pointed out in the 2020 report, there is real concern across the sector that the HESCET tool conflates emissions with financial cost and does not reflect the true supply chain emissions in an accurate way.

*Waste*

Academic/estate waste data was based on a document Veolia provided by the constructors. Data contained presents data for the period June 2019 – July 2021 regarding non-hazardous waste, animal bedding, recycling, wood, paper, glass, cardboard, and food waste. Data for waste electrical and electronic equipment (WEEE) was collected from receipts from waste collection. Weight in metric tonnes for each category was multiplied by the appropriate Defra emission factor to calculate the $CO_2$ equivalent emissions ($kgCO_2e$). Results are presented in **Table 1**.

| | 2018 | | 2019 | | 2020 | | 2021 | |
|---|---|---|---|---|---|---|---|---|
| | kgCO2e | % | kgCO2e | % | kgCO2e | % | kgCO2e | % |
| Non-Hazardous Industrial | 4526.56 | 25.9 | 8777.39 | 31.6 | 5168.28 | 29.4 | 3435.91 | 18.9 |
| Animal Bedding | 9904.40 | 56.7 | 11105.67 | 40.0 | 7734.14 | 43.9 | 8792.41 | 48.3 |
| Cardboard | 124.03 | 0.7 | 237.45 | 0.9 | 170.17 | 1.0 | 197.99 | 1.1 |
| Food Waste -not by animal product | 3.21 | 0.0 | 35.19 | 0.1 | 172.54 | 1.0 | 1440.10 | 7.9 |
| Glass - Mixed | 23.95 | 0.1 | 68.33 | 0.2 | 0.00 | 0.0 | 270.66 | 1.5 |
| Metals -Mixed | 0.00 | 0.0 | 34.59 | 0.1 | 57.23 | 0.3 | 171.68 | 0.9 |
| Paper -Mixed | 143.27 | 0.8 | 1362.80 | 4.9 | 663.68 | 3.8 | 768.74 | 4.2 |
| Recyclate - Mixed | 2582.23 | 14.8 | 5888.72 | 21.2 | 3430.40 | 19.5 | 2974.58 | 16.4 |
| Wood - Grade A | 163.38 | 0.9 | 244.29 | 0.9 | 201.58 | 1.1 | 138.37 | 0.8 |
| **TOTAL** | **17471.02** | **100.0** | **27754.44** | **100.00** | **17598.01** | **100.0** | **18190.46** | **100.00** |

**Table 1.** Annual distribution of GHG emissions [kgCo2e] from academic waste 2018-21

Residential waste data were provided by Biffa for 2019 – 2020 and comprises information for general waste, food waste, DMR waste, glass waste, mattress, and green waste for the period August 2019-May 2020. Food waste is only noted from Cartwright Court. The measured weight of waste was multiplied by the appropriate Defra emission factor to calculate the $CO_2$ equivalent emissions ($kgCO_2e$/ $tCO_2e$). The electrical and electronic equipment waste (WEEE) data was provided in annual increments for academic years 15/16, 16/17, 17/18, 18/19 and 19/20. **Table 2** summarises these data for 2020.

Due disparities in the quality, quantity, and general amount of data available regarding waste it is difficult to make a straightforward analysis to allow comparison with previous years. The only period for which there seems to be data from all types of wastes and departments is the academic year 19/20 for which the total GHG emissions from waste was estimated at 38.92 tCO2e. This suggests a decrease from the average of 56 tCo2e from years 2017-19 and an 87% decrease from the baseline established for the academic year 12/13.

Overall, these data – which have been estimated in an extremely rigorous manner, but which are nonetheless only as reliable as the data available, suggest **a split in Scope 1, 2 and 3 emissions of 7.5%, 6.3% and 86.2%, respectively. Crucially, however, these Scope 3 estimates for 2020 do not include staff or student travel.**

| | 19/20 | |
|---|---|---|
| | tCO2e | % |
| **General waste** | 9.1 | 58.9 |
| **General waste skips** | 0.3 | 1.8 |
| **Food waste** | 0.1 | 0.4 |
| **DMR waste** | 4.0 | 25.7 |
| **Glass waste** | 1.2 | 8.0 |
| **Mattress** | 0.3 | 2.1 |
| **Green waste** | 0.3 | 1.9 |
| **WEE** | 0.2 | 1.1 |
| **TOTAL** | **15.4** | **100.0** |

**Table 2:** Academic waste 2019/2020

**Travel**

Tasarla and Daniel worked on a variety of aspects of staff and student travel. Tasarla focused on UK student commuting behaviour. Cardiff University currently has 23,785 UK-resident students[1]. Data for UK-resident students commuting to Cardiff university from their term-time address was collected in November-December 2021 with a short student survey designed by Tasarla with input from Richard Wintrip and colleagues and completed by a total of 348 students. The number of days students usually come into the university per week, mode of travel, school, and term-time address were collected and the road distance of their commutes was calculated. This was then combined with the DEFRA emissions factors for each mode of transport to produce the data for the annual kgCO2e (kg of CO2-equivalent GHG) produced by students on their commute. This analysis estimates that the total emissions of UK-resident students commuting to their school building from their term-time address over the course of a year is **2,453 tCO2e** (approx. 0.10tCO2e per student, **Table 3**). This was calculated with the following equation

$$Annual\ tCO2e\ of\ population = \frac{Anuual\ tCO2e\ of\ sample}{Sample\ size} \cdot population\ size$$

**Table 3:** break-down of the emissions by transport method given below.

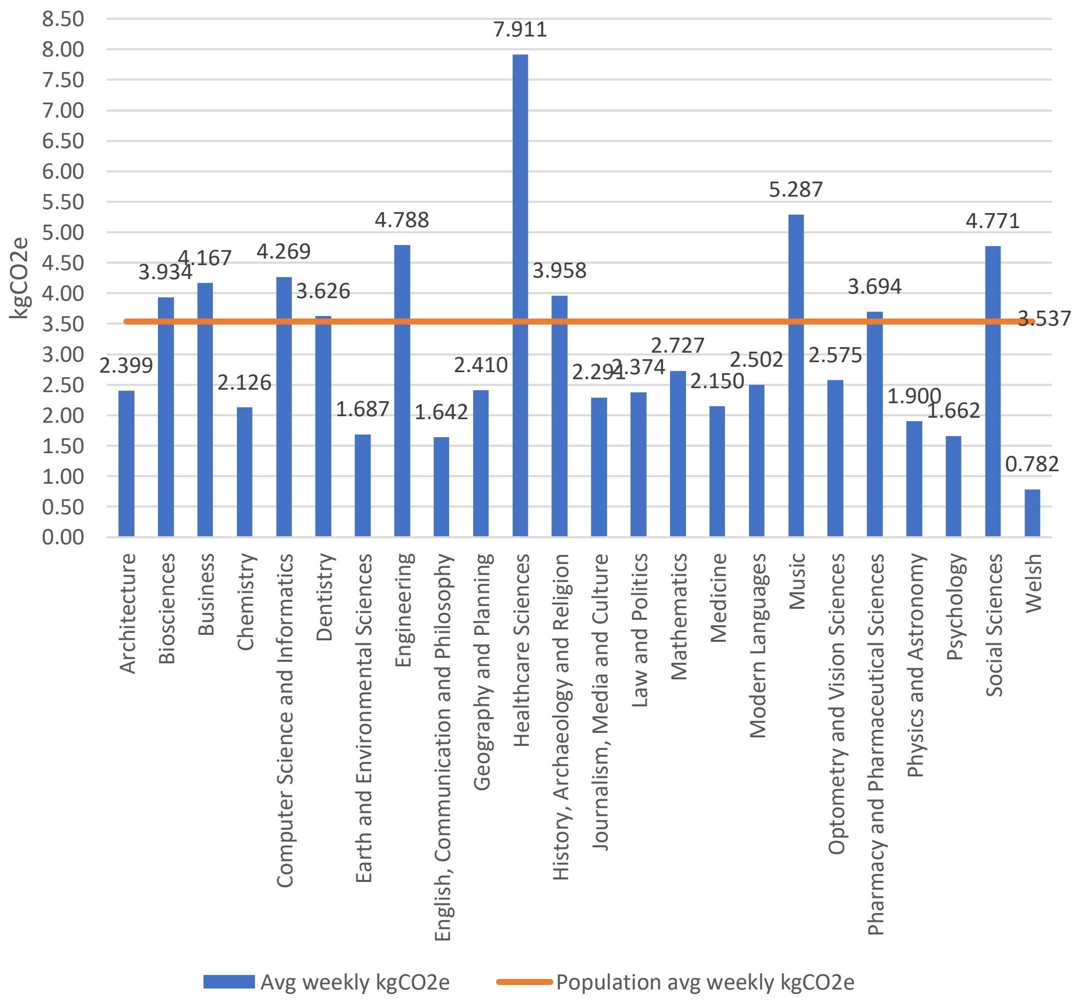
| **Transport Method** | **Percentage of students travelling by this method** | **Annual tCO2e produced by students travelling with this method** |
|---|---|---|
| Bus | 4.598% | 105.95 |
| Cycling | 7.759% | 93.14 |
| Cycling (using a shared bike scheme such as NextBike) | 0.287% | 1.22 |
| Driving | 8.333% | 449.68 |
| Lift share | 2.874% | 348.79 |
| Motorbike / moped | 0.287% | 27.82 |
| Taxi | 0.575% | 8.29 |

[1] https://www.cardiff.ac.uk/about/facts-and-figures

| | | |
|---|---|---|
| Train | 9.483% | 463.67 |
| Walking | 64.655% | 836.58 |
| Other | 1.149% | 118.34 |
| | | |
| **Total** | | **2,453.48** |

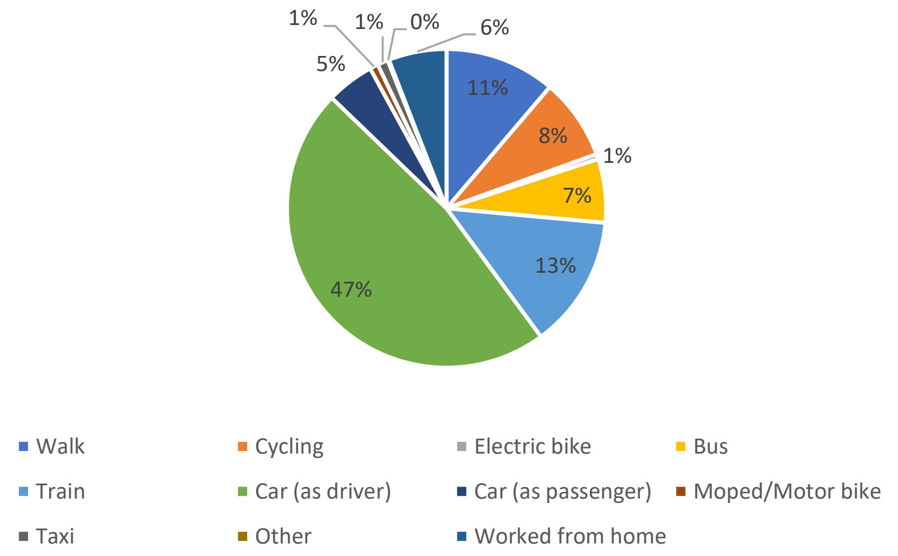
An analysis of several covariables was also undertaken. These were compared to weekly emissions and transport methods and were gender, Under/Post-graduate, Part/Full-time, Age and School. The most notable trend found in this analysis was that students in Healthcare Sciences have the highest average weekly kgCO2e produced by a large margin. This is likely due to the school having the highest average distance of commute and the highest proportion of students commuting by car. This is likely due to the nature of the courses offered by Healthcare Sciences, which require students to travel to various hospitals and labs at a variety of times and on the weekend (**Figure 8**). The small sample size may have biased these results, however given the time available they provide a useful summary of current student commuting practice.

**Figure 8:** Averge Weekly kgCO2e Emissions per Gender vs Population Average Weekly kgCO2e



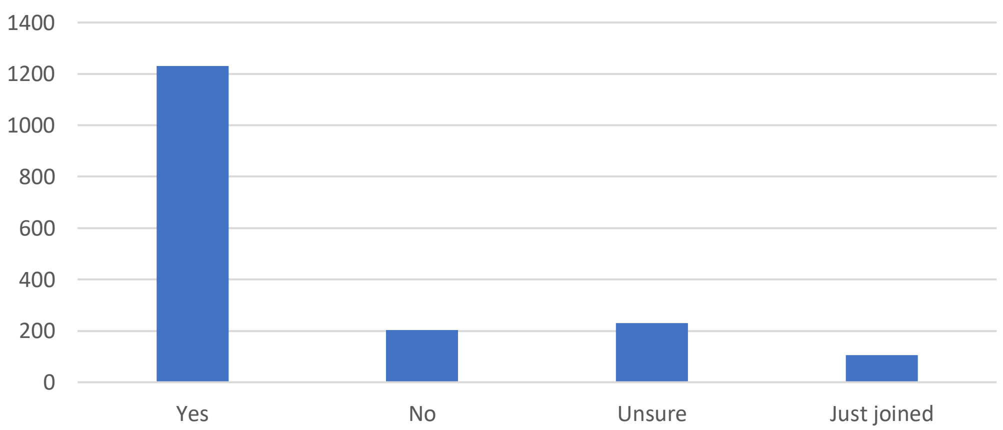
Daniel focused on analysing the data from the staff commuting survey (that is undergoing more thorough analysis by the Travel Plan refresh team currently). He summarised the results by School and overall. The School-specific data are on the excel spreadsheet in Teams and the overall data are summarised below. It should be noted that the questionnaire (c1800 participants) were predominantly completed (c1300) by staff applying for a car parking permit, and who therefore may have a specific viewpoint when it comes to commuting. A disaggregated analysis of the 500 staff who completed the questionnaire might provide a different viewpoint. **Figure 9** details the overall breakdown of staff responding to question 18 of the questionnaire – how do you currently travel to work?

**Figure 9**: Current Staff Travel Patterns



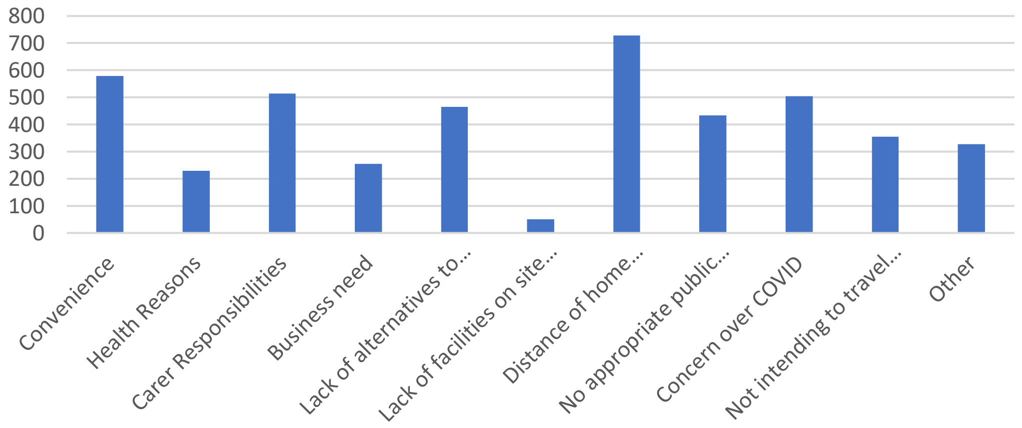

It can be seen that over 50% of respondents who travel to the University come by car currently (either driving or as a passenger), with 24% walking or taking the train. Furthermore, when asked the question "Are you intending to revert to your previous mode of transport for 2021/2022?" the large majority said yes (**Figure 10**). When asked why this was the case, the

**Figure 10**: are you intending to revert to your previous mode(s) of travel for the new academic year (2021-2022)?



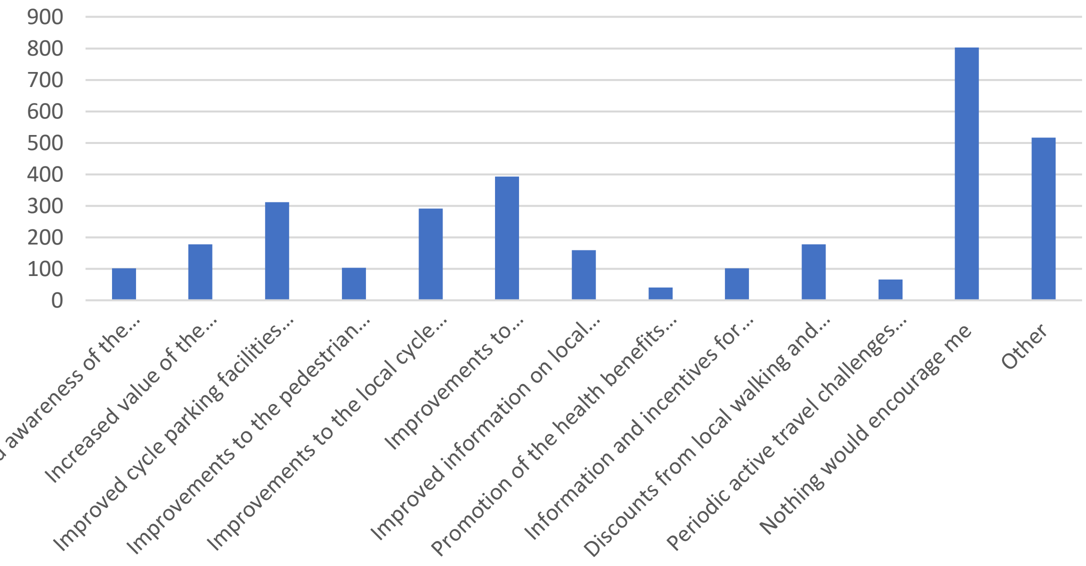
Respondents were fairly evenly split across a number of categories, including distance from home, convenience, caring responsibilities, lack of alternatives/no appropriate alternative mode and COVID concerns (**Figure 11**).

**Figure 11**: if you are intending to travel to / from work by car for the new academic year (2021-2022) what are your main reasons for this mode choice?




Further, when asked the question "what would encourage you to use active modes of transport for travel to and from work?", a large proportion of respondents did not foresee a reason why they would change to active transport (**Figure 12**). This was followed by the need for improvements to shower and changing facilities, improvements to the cycle network on campus and improvements to the cycle to work scheme (usually an increase of loan value to include e-bikes).

**Figure 12**: which of the following measures would most encourage you to use active modes of travel (e.g. cycling, walking or running) to travel to / from work?




Daniel was also able to estimate the current emissions from staff commuting using the survey data with respondents' home postcode included. He was able to break this analysis down to annual emissions before the pandemic, during the pandemic and after the pandemic. The results are: 1414 tCO2e, 745 tCO2e and 1281 tCO2e, respectively. **This shows an approximately 50% drop in emissions during the pandemic** but likely a fairly rapid reversion to 90% of pre-pandemic values based on intended behaviour if travelling with the same frequency. It is important to note that these estimates are calculated from the returns only. Daniel also designed a foreign student travel survey which is currently being responded to.