Complexity in measuring the higher education institution scope 3 emissions.

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Complexity in measuring the Higher Education Institute Scope 3 emissions

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ABSTRACT

The first step in addressing climate change is to measure carbon emissions derived from GHGs. The greenhouse gas protocol is widely accepted and implemented by organisations worldwide. This protocol categorises carbon emissions into three scopes: scope 1, scope 2, and scope 3. Reporting of scope 1 and scope 2 emissions has become more streamlined, and many organisations report them consistently year after year, making it mandatory. However, the methodology for reporting scope 3 emissions is often ambiguous, with undefined boundary conditions and the potential for double counting. These factors make the calculation of scope 3 emissions more complicated. Reporting of scope 3 emissions is voluntary for organisations. Research has shown that scope 3 emissions, which account for indirect emissions including those from the supply chain, employee commuting, business travel, and waste disposal, can contribute up to 65% of an organisation's carbon footprint.

By not reporting scope 3 emissions, organisations are significantly underreporting their overall emissions. To achieve the goal of net-zero emissions by 2050, it is crucial to accurately record, measure, and estimate scope 3 emissions. This study focuses on Scottish higher education institutes as a case study to better understand the complexities involved in measuring scope 3 emissions. It delves into each complexity and develops methods to mitigate and streamline the estimation methodology.

This thesis employs correlation analysis, normalisation techniques, peer comparison, and benchmarking methods to gain insights from the data. The results section reveals that the majority of Higher Education Institutes only report emissions related to grid transmission and distribution, water supply and treatment, recycling, and waste disposal. These sources represent a small portion, contributing only 11% of total scope 3 emissions. As a result of selective reporting, eight out of seventeen HEIs have reported scope 3 emissions that account for less than 20% of their total emissions. Travel-related emissions and procurement emissions together constitute the major portion (89%) of scope 3 emissions. However, there is little evidence to suggest that Higher Education Institutes are actively estimating these emissions. As an example, the scope 3 emissions of Robert Gordon University were calculated in this study, revealing that the calculated emissions were six times higher than what was initially reported. The Robert Gordon University did not report significant components of scope 3 emissions, such as procurement, international student travel, and staff-student commute, which were included in the revised calculations.

This thesis has introduced a novel benchmarking methodology for scope 3 reporting, aiming to enhance the reporting structure and promote the adoption of best practices. The benchmarking score ranges from 0 (representing the worst performance) to 1 (representing the best performance). Higher Education Institutes are evaluated based on the quality of their reporting, including factors such as completeness, consistency, inclusions, and accuracy. Among the higher education institutes, Glasgow Caledonian University and University of Edinburgh emerged as the top performers, receiving benchmarking scores of 0.47 and 0.27 respectively. On the other hand, University of West of Scotland, Queen Margaret University, and Abertay University were identified as the lowest performers. By implementing the best practices in scope 3 estimation, the reporting performance score of Robert Gordon University was determined to be 0.57.

Lastly, the impact of the COVID-19 pandemic on emissions recording was evaluated. It was observed that several institutes did not exhibit sufficient reduction in emissions during the COVID-impacted years, suggesting potential issues with data recording or energy wastage despite minimal operations.

Keywords: climate change, carbon emissions, scope 3 emissions, emission uncertainty, HEI emissions, benchmarking emissions, RGU emissions, covid emissions

DEDICATION

This thesis is dedicated to my late supervisor Professor Edward Gobina, who helpd me through this difficult journey. I would also like to thank my wife, Amita Nayak and mother Vasanthi Nayak for constantly supporting me personally during this journey. I would also like to thank my friends Pratik Bhonsule, Ranjan Ramdas and Prashant More for encouraging me through out the PhD journey.

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ABBREVIATIONS

ACUPCC	American College & University Presidents' Climate Commitment
AU	Abertay University
BECE	Back casting and eco-design for Circular Economy
CFC	Chlorofluorocarbons
CMP	Carbon Management Plan
CO2e	Carbon dioxide equivalent
COP26	United Nations Climate Change Conference
COVID	Coronavirus disease 2019
DEFRA	Department for Environment, Food and Rural Affairs
ENU	Edinburgh Napier University
FTE	Full time equivalent
FTES	Full Time Equivalent Student
GBP	Great Britain Pound
GCU	Glasgow Caledonian University
GgCO2e	Gigagram Carbon dioxide
GHG	Greenhouse gas
GSA	Glasgow School of Arts
GU	Glasgow University
GWP	Global Warming Potential
HEFCE	Higher Education Funding Council for England
HEI	Higher Education Institute
HESA	Higher Education Statistics Agency
HWU	Heriott Watt University
ICT	Information Communication Technology
IQR	Inter Quartile Range
ISO	International Organisation for Standardization
Kg CO2e	Kilogram Carbon dioxide equivalent
KPI	Key Performance Indicator
LCA	Life cycle assessment
QMU	Queen Margaret University
RF	Relatively Higher Radiative Forcing Factor
RGU	Robert Gordon University
S&T	Supply and Transport
SCM	Strategic Carbon Management
SRUC	Scotland Rural College
SSN	Sustainable Scotland Network

St Andrews University	Saint Andrews University
STEM	Science, Technology, Engineering and Mathematics
SU	Stirling University
T&D	Transmission and Distribution
UCCCfs	Universities and Colleges Climate Commitment for Scotland
UHI	University of Highland and Island
UK	United Kingdom
UN	United Nations
UoA	University of Aberdeen
University of Dundee	University of Dundee
University of Edinburgh	University of Edinburgh
UoSt	University of Strathclyde
UWS	University of West Scotland
WRI	World Resources Institute

UNITS

GWh	Giga Watt-hour
kWh	Kilo Watt-hour
m2	Meter square
m3	Meter cube
MtCO2	Metric tonne carbon dioxide
MtCO2e	Metric tonne carbon dioxide equivalent
MWh	Mega Watt-hour
N2O	Nitrous Oxide
O3	Ozone
tCO2e	Tonnes of Carbon dioxide

CHEMICAL FORMULA

CH_4	Methane
CO_2	Carbon dioxide
N_2O	Nitrous Oxide

1. Introduction

1.1 Background

The combustion of fossil fuels has led to the extensive exploitation of limited natural resources on a global scale. It is well-established that the combustion of fossil fuels releases Greenhouse gasess (GHG) into the atmosphere, which trap heat and lead to global warming. The most important GHGs are water vapor, carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), ozone (O3), and chlorofluorocarbons (CFCs). While the Earth reflects some of the sun's rays back into space, GHGs absorb these rays and trap them in the atmosphere, which warms the planet. CO2 is the most abundant GHG in the atmosphere, and it has the greatest impact on climate change (EPA, 2016). While some geological factors may contribute to climate change, human activities are the primary cause of the current warming trend (IPCC, 1992). The Intergovernmental Panel on Climate Change (IPCC) concluded that human activities are the main cause of the emission of GHGs and subsequent climate change.

Global emissions was 35 billion tonnes of carbon dioxide equivalent (tCO2e) in 2020 as compared to 6 billion tonnes in 1950 (IEA, 2022). During the early stages of the industrial revolution in the 19th century, industrialised countries were the main contributors of CO2e.The industrial revolution has exerted tremendous pressure on the Earth's natural climate, leading to an erratic weather system. Poorer and marginalised nations that did not contribute to carbon emissions are disproportionately suffering from the effects of climate change. Additionally, there will be an increase in the frequency of crop failures, forest fires, and extreme flooding. Two hundred nations recently met in Glasgow for the 26th Conference of the Parties (COP26) to the United Nations Framework Convention on Climate Change (UNFCCC), where they debated ways to keep the global temperature below 2 degrees Celsius (UN, 2020). The UK government has set an ambitious goal of lowering carbon emissions by 78% by 2035 compared to the baseline year of 1990. The UK governemnet has extended this responsibility by aiming for net zero nation status by 2050. The UK wants to reach the net zero goal by emphasizing green technology, making big polluters pay, protecting the weak, and ensuring a smooth transition (UK, Gov, 2021). In 2019, the UK emitted 454.8 million tonnes of carbon dioxide equivalent (MtCO2e), of which 25% was from the built environment (DEFRA, 2019; UKGBC, 2022). The UK Higher Education Institutes (HEIs) have been the cradle of world knowledge for several centuries, and it is home to some of the oldest functioning universities in the world, including Oxford University, the University of Edinburgh and the University of Aberdeen. These universities are spread over a vast area with ancient architecture, and they have the knowledge and innovation capabilities to tackle the global climate change problem.

UK HEIs are at the forefront of estimating and reporting their carbon emissions, which could pave the way for national net-zero emissions. Each HEI acts as a micro-region, with its own geographic area, varying number of building, energy consumption, open space, owned vehicles, staff-student commutes, and business travel.

1.2 Why scope 3 emission is important?

Scope 1 and scope 2 emissions are directly caused by an organisation's regular operations. Indirect scope 3 emissions have the largest impact on the organisation's overall carbon footprint, but they occur outside the organisation's boundaries and are not under the control of the operations. As a result, organisations have limited ability to directly control scope 3 emissions. If they want to reduce scope 3 emissions, they must negotiate with service providers and jointly implement carbon reduction initiatives.

If only scope 1 and scope 2 emissions are accounted for in the total carbon footprint, then an organisation can easily reduce the total carbon footprint by outsourcing its key activities to an outside party. As a result, emissions generated within the organisation are released into another organisation. Therefore, organisations must assume full responsibility for their actions and the effects they have on the environment. In the case of HEIs, several activities lead to indirect emissions. For example, HEIs attract many international students who fly to campus, and the emissions from these flights are the responsibility of the HEI. The same is true for staff and student commutes, which are also considered scope 3 emissions. The HEI's equipment and supplies have also produced and released significant volumes of CO_2 at other locations where they were extracted and manufactured. All of the upstream emissions of goods purchased, including power, are the responsibility of the HEIs. The complete travel-related and purchased item emissions are rarely reported by any HEI. According to the literature, they may contain up to 70% of the organisation's carbon footprint. If scope 3 emissions are neglected, the viability of the HEI's carbon reduction initiatives will be severely undermined. Currently, scope 3 reporting is voluntary and optional, but as the country moves towards the net-zero target, it will become mandatory to report all emissions, including scope 3 emissions.

Before making scope 3 emissions mandatory, it is essential to streamline the reporting methodology and make calculation steps more objective. It is also important to minimize the uncertainty around the analysis of scope 3 emissions. This thesis explores the complexities associated with reporting scope 3 emissions and proposes a method to estimate HEI scope 3 emissions with limited data.

1.3 Research objectives

The following research objectives are identified for this thesis:

1.3.1 Exploratory data analysis of scopes 1, 2 & 3

To comprehend the emissions profile of UK HEIs, an exploratory data analysis is conducted for scopes 1, 2, and 3. This study takes a broad and aggregated approach to identify the key drivers of emissions and their patterns over a span of five years. The data for this analysis is obtained from the Higher Education Statistics Agency (HESA), where each UK HEI reports its emissions. Correlation analysis and normalised emissions comparison are employed to evaluate the performance of the HEIs. However, it is important to note that this thesis does not undertake an in-depth examination of each individual UK HEI. Instead, the focus is on comparing the aggregate emissions of the UK HEIs to the benchmark emissions reduction target of 43%.

1.3.2 Scottish HEI scope 3 reporting analysis

The scope 3 emission data for Scottish HEIs is obtained from the Sustainable Scottish Network (SSN). The SSN website provides comprehensive access to all reports and submissions by Scottish HEIs regarding their emissions. The emissions report, presented in the form of a spreadsheet, contains cumulative scope 1, 2, and 3 emissions for both the current and previous years. It also offers a summary of the emission sources for scopes 1, 2, and 3.

The research emphasises the intricacies of scope 3 reporting, including aspects related to consistency, data quality, quality enhancement, and data granularity. Through thorough analysis, this research sheds light on the challenges faced by HEIs when estimating scope 3 emissions. Furthermore, it aids in identifying the primary sources of scope 3 emissions, enabling HEIs to prioritize efforts in addressing these high-emitting sources. The insights gained from this study have the potential to improve scope 3 emission estimation practices and contribute to sustainability efforts within the higher education sector in Scotland and beyond.

1.3.3 Estimating scope 3 emissions for RGU

Scottish HEIs submit their scope 3 emissions data to the Sustainable Scottish Network (SSN); however, there is a lack of seriousness in their reporting. Consequently, many HEIs only provide partial scope 3 emissions, opting for easily accessible and simple reporting methods. This thesis aims to delve into the scope 3 emissions of Scottish HEIs, identify best practices, and develop a methodology to estimate scope 3 emissions using peer analysis.

The thesis employs RGU (Robert Gordon University) as a case study HEI, where the newly developed methodology is applied to estimate its scope 3 emissions. This exercise demonstrates that even with sparse data and approximate scope 3 estimates, emissions can be calculated. The approach employed in this study leverages the results from research objective 2 to achieve this goal

1.3.4 Benchmarking of the Scottish HEI based on their scope 3 emissions reporting

The output of research objectives 2 and 3 are used to benchmark Scottish HEIs based on parameters such as completeness, quality, consistency, and accounting for COVID-19.
The breakdown of the benchmarking score further enables HEIs to identify specific areas that require improvement to effectively address all carbon emissions. By understanding their strengths and weaknesses relative to their peers, HEIs can implement targeted measures to enhance their emission

reporting practices, promote data accuracy and consistency, and develop strategies to mitigate carbon emissions effectively.

Overall, this benchmarking process contributes to fostering a culture of continuous improvement and sustainability within the higher education sector in Scotland, leading to more robust and reliable scope 3 emission estimates and a collective effort towards carbon neutrality and environmental responsibility.

1.3.5 Impact of COVID

The impact of COVID-19 on scope 3 emissions is thoroughly analysed using the findings from research objective 2. The nationwide lockdown measures during the pandemic resulted in the complete suspension of operational activities. As a consequence, there was a significant reduction in emissions, particularly with regard to scope 3 emissions.

This thesis investigates the reporting practices adopted by HEIs to monitor emissions during the lockdown period and how they reported scope 3 emissions. By delving into these reporting practices, the study aims to understand how HEIs adapted to the unique circumstances brought about by the pandemic and how they accounted for the drastic changes in emissions patterns.

The analysis in this thesis sheds light on the challenges and opportunities that emerged during the COVID-19 lockdown, providing valuable insights into how HEIs managed and reported their emissions in response to the unprecedented situation. By examining the reporting practices related to scope 3 emissions during this exceptional period, the study contributes to a better understanding of the broader implications for emission tracking and sustainability measures in the face of unexpected disruptions.

1.4 Thesis structure

The thesis is structured in the following way:

***Chapter 2*: Literature review**

The literature review chapter explores the current state of knowledge on several key topics related to carbon management plans, scope 3 emissions, and HEIs reporting practices in the context of scope 3 emissions.

Carbon management plan: It provides an overview of various strategies and measures that organisations, including HEIs, employ to manage and reduce their carbon footprint. This includes discussing the importance of carbon management plans in addressing climate change and achieving sustainability goals.

Scope 3 emissions: In this part, the literature review delves into the concept of scope 3 emissions, which encompasses indirect emissions associated with an organisation's activities but occur outside its operational boundaries. It explores the different categories of scope 3 emissions and their significance in understanding the full carbon impact of an organization, including HEIs.

HEI reporting of scope 3 emissions: This section focuses on the existing literature related to HEIs' reporting practices regarding scope 3 emissions. It analyses the methods and approaches HEIs use to track, measure, and report their scope 3 emissions data. Additionally, it discusses the challenges and limitations faced by HEIs in reporting scope 3 emissions accurately.

Identifying knowledge gaps: The literature review identifies gaps in the current body of knowledge related to carbon management plans, scope 3 emissions, and HEI reporting practices. These gaps represent areas where further research and investigation are needed to enhance understanding and fill existing knowledge voids. By identifying these gaps, the study outlines the rationale and significance of the research objectives in addressing these specific areas of interest.

***Chapter 3*: Methodology**

This section describes the methodology used to explore the complexities of estimating scope 3 emissions for Scottish HEIs. It outlines the data collection process, sources of data, and the criteria used to select the sample of HEIs for the analysis. Additionally, any assumptions made during the data collection and sample selection process are explicitly stated.

This section also describes the methodology used to assess the data quality, consistency, and enhancement techniques related to scope 3 emissions reporting. It details the statistical methods utilised to analyse the data, such as correlation analysis and normalisation techniques. The section highlights the assumptions made while conducting the analysis and interpreting the results.
Furthermore, describes the methodology employed to benchmark Scottish HEIs based on completeness, quality, consistency, and accounting for the impact of COVID-19. It elucidates the steps taken to derive the benchmarking score and the statistical techniques used for comparison. Any underlying assumptions in developing the benchmarking score are explicitly mentioned

***Chapter 4*: Explolatory data analysis – Scope 1, 2 and 3 emissions**

The chapter on exploratory data analysis conducts an in-depth examination of the scope 1, 2, and 3 emissions for all UK HEIs combined. It aims to provide insights into the emissions patterns and identify the various factors influencing scope 3 emissions.

The chapter begins by describing the data analysis process, including the data sources and the methods used to gather and preprocess the emissions data from all UK HEIs. It discusses the scope 1, 2, and 3 emissions data over a specified time period and examines trends and variations in the emissions levels.

The chapter presents graphical representations, such as charts, graphs, and plots, to visualize the emissions data and illustrate the relationship between different emissions sources and the overall scope 3 emissions. Additionally, statistical analysis techniques may be applied to determine the extent of influence that various factors have on scope 3 emissions.

By conducting this exploratory data analysis, the chapter provides valuable insights into the emissions profiles of UK HEIs and the key drivers of their carbon footprints. These findings can help inform carbon management strategies, sustainability initiatives, and policy decisions aimed at reducing scope 3 emissions and promoting environmental responsibility within the higher education sector.

***Chapter 5*: Scope 3 emissions reporting by the Scottish HEIs**

This chapter does a detailed analysis of scope 3 emissions reporting by Scottish HEIs and conducts a comprehensive investigation into the reporting practices of each HEI over a period of five years, spanning from 2016 to 2021 (wherever data is available). The primary focus is on understanding the structure of scope 3 emissions reporting and identifying patterns of consistencies and inconsistencies across the years.

The chapter begins by outlining the data collection process, which involves gathering scope 3 emissions reports from each Scottish HEI for the specified period. The collected data is then subjected to thorough analysis to understand how scope 3 emissions are reported by each institution over time.

The analysis delves into the reporting structure of each HEI, examining how they categorise and present scope 3 emissions data. It investigates whether there are any changes or improvements in reporting practices over the five-year period and how these changes may impact the accuracy and consistency of emissions calculations.

The findings from this detailed analysis help to reveal areas where HEIs may need to enhance their reporting practices to ensure greater consistency and data quality. It also sheds light on challenges faced by institutions in estimating scope 3 emissions accurately and provides valuable insights for improving reporting standards.

Overall, the chapter contributes to a deeper understanding of the complexities involved in scope 3 emissions reporting by Scottish HEIs and serves as a foundation for the subsequent research objectives, including identifying best practices and developing methodologies for estimating scope 3 emissions in a more robust and reliable manner.

***Chapter 6*: Calculation of RGU scope 3 emissions**

In this chapter, the revised scope 3 emissions are calculated, for RGU, based on the findings from chapters 4 and 5. The calculation process utilises the best practices identified in chapter 4, which includes the improved reporting structures and data quality enhancements recommended based on the analysis of HEIs' scope 3 emissions reporting practices. These best practices are designed to ensure greater consistency, accuracy, and completeness in the reporting of scope 3 emissions. By combining the best practices and peer analysis results, the chapter aims to calculate the revised scope 3 emissions that cover as many emission sources as possible. This comprehensive approach ensures that a more realistic and accurate figure for scope 3 emissions is derived. Ultimately, the results from this chapter contribute to a better understanding of the overall carbon footprint of RGU and facilitate informed decision-making and strategic planning to reduce and manage their scope 3 emissions effectively.

***Chapter 7*: Benchmarking of Scottish HEI**

In this chapter, the findings from all the previous chapters are utilized to develop a benchmarking score for each Scottish HEI. The purpose of this benchmarking score is to provide a standardised and generic measure that can be applied not only to Scottish HEIs but also to HEIs outside Scotland, making it transferable and adaptable to different contexts.

The development of the benchmarking score incorporates various parameters derived from the previous chapters, including the detailed analysis of scope 3 emissions reporting (chapter 4), identification of best practices (chapter 4), peer analysis (chapter 5), and the calculation of revised scope 3 emissions (chapter 6).

These parameters may encompass factors such as completeness of scope 3 emissions reporting, data quality and consistency, adherence to best practices, incorporation of COVID-19 impact, and performance relative to peers. Each parameter contributes to the overall assessment of an HEI's scope 3 emissions performance.

The formula for calculating the benchmarking score is carefully crafted to be generic, allowing it to be applied to HEIs beyond the Scottish context. It is designed to provide a quantifiable measure of each institution's emissions management efforts, with a scale ranging from 0 to 1. A score of 0 indicates poor emissions management performance, while a score of 1 reflects excellent performance.

By utilizing a standardized benchmarking score, this chapter facilitates the comparison and evaluation of different HEIs' efforts in managing scope 3 emissions, offering a valuable tool for sustainability assessments and strategic decision-making. The benchmarking score serves as a useful metric for institutions to gauge their progress, identify areas for improvement, and work towards achieving higher levels of emissions reduction and environmental responsibility.

***Chapter 8*: Conclusion**

This is the concluding chapter which summarises the research objectives, methodologies, results and how these results answers the research objects. It also highlights the knowledge gap and the novel contribution to the knowledge.

2. Literature review

2.1 Background

HEIs are artificial man-made structures that fall under the built environment umbrella. The built environment accounts for 40% of total energy usage worldwide (ECTP, 2005). In 2019, HEIs in the UK used 7,416 megawatt-hours (MWh) of energy and released 1.6 million tonnes of carbon dioxide equivalent (CO_2e), which is equivalent to 4.6% of the UK's total CO_2e emissions (HESA, 2020; DBEIS, 2019).The liability for CO_2e emissions compels HEIs to take proactive steps to mitigate the harmful effects of their actions. HEIs exert significant influence on the local population, economic growth, and social dynamics, all of which enhance the institution's reputation within the community. The HEIs also possess the technical expertise required to develop and implement environmental policies without significantly disrupting the existing human resources. This technical know-how can be used to create and carry out environmental policies without substantially altering the current staff. The above reasons make a solid case for HEIs to reduce their carbon emissions, contribute to the national emissions target, and influence others by developing innovative building techniques and practices (Robinson et al., 2017; Altans, 2010).

Experts generally agree that businesses need to reduce their carbon emissions. In response to this, numerous organisations, including HEIs, have adopted policies and carbon control programs. Although there are a few international regulations (such as the GHG Protocol and ISO standards) that provide guidance on how to calculate carbon emissions, these standards are general and allow for a great deal of flexibility. As a result, different organisations may implement their carbon control programs in very different ways. This variability can make it difficult to compare the performance of different organisations and to assess the overall effectiveness of carbon control programs. In addition to variability, there is also a risk of bias in carbon control programs. This is because organisations may have an incentive to present their carbon emissions in a favorable light. For example, an organisation may choose to exclude certain emission-causing activities from its carbon plan, or it may use a methodology that underestimates its emissions. Kenny and Gary (2009) argued that this variability and bias in carbon plans gives an edge to specific organisations. They argued that these organisations can present the results of their carbon plans in a way that meets their objectives, even if their actual emissions are not being reduced. This is a serious problem, as it undermines the effectiveness of carbon control programs. It is important for organisations to be transparent about their carbon emissions and to use a consistent methodology for calculating their

emissions. In contrast, Tompkins and Adger (2004) argued that each organisation is different and that enforcing the same carbon strategy may not be advisable. Instead, the scale of implementation must be consistent, and criteria must be used to measure each scale. Mazhar et al. (2014) proposed the need for a framework that can communicate the translation of carbon reduction objectives into the organisation's strategic goals, which is lacking in HEIs at present. In the case of UK HEIs, the Higher Education Funding Council for England (HEFCE, now known as HESA) and the Universities and Colleges Climate Committee for Scotland (UCCCfS) are the governing bodies responsible for overseeing the performance and compliance of HEIs in England and Scotland, respectively. HEFCE (also known as HESA) previously set a 2020 milestone for HEIs to reduce emissions by 43% of their 2005 levels.
Similarly, the UCCCfS has set a target of 80% reduction by 2050. The HESA guidelines have also linked HEIs' funding to their carbon management strategy (HESA, 2020). This approach motivates HEIs to integrate their carbon strategy with the organisation's strategic objectives. However, HEIs face challenges in effectively translating carbon reduction objectives into strategic goals (Mazhar et al., 2012). The Carbon Management Plan (CMP), a voluntary system, provides the framework for HEIs to report their emissions. Since participation is voluntary, there is no predetermined goal. HEFCE has established rules based on these CMP, but Altans (2010) criticised the HEFCE strategy for its leniency. In cases where HEIs have poor carbon strategy or monitoring, the penalties are minimal. The Bright-Green report (2016) summarizes the progress of English HEIs toward achieving the 2020 emissions target. The analysis concludes that HEIs are likely to fall short of the emission targets and, based on the current trend, they are projected to achieve only a 23 percent reduction instead of the targeted 43 percent reduction. Due to the COVID-19 pandemic, most on-campus operations of UK HEIs were suspended in 2020, with a majority of activities, including teaching, transitioning to online platforms.

According to the HEFCE and UCCCfS recommendations, UK HEIs are required to create a CMP outlining their strategy and action plan to fulfill their commitment to reducing carbon emissions. The CMP has already been developed by every HEI in the UK that is committed to reducing emissions. Because the HEIs' sizes and areas of specialization vary, the CMP will also vary. Nevertheless, the CMP in general (including the CMP for HEIs) must include the following (DERA, 2020):

- The base year or benchmark year emission. In the case of HEIs in England, it is 2005. The emissions calculation must include at least scope 1 and scope 2 emissions.
- The CMP must also include target emissions for the year 2020. Setting a target for scope 3 emissions is voluntary.

- An action plan on how to achieve the target emissions
- The responsibilities for various actions within the action plan.
- Carbon reduction progress monitoring framework to be used to update the status periodically
- Sign off by the governing body of the CMP.

The CMP is an important tool for HEIs to reduce their carbon emissions and to meet their sustainability goals. By following the guidelines outlined in the CMP, HEIs can make a positive impact on the environment and on the future of their institutions.

Mazhar et al. (2019) conducted a qualitative and inductive content analysis of the carbon management plans (CMPs) of 18 UK HEIs. The results showed that the CMPs are consistent in design, making it relatively straightforward to compare HEIs. However, the authors observed that the CMPs have technically dominant content, as they are typically developed by environmentalists or technical managers. This makes it difficult for non-technical people to understand the CMPs. Additionally, the CMPs are often not given enough attention, as they are created independently of business strategy. They are sometimes revised, but only after long periods of time, such as 10 years. Finally, there is no reporting of the progress of the CMP action plan, which allows HEIs to miss their targets despite mentioning them in the document.The CMP's top-down structure and lack of interactive communication between stakeholders make it challenging to implement policies, according to the author. Mazhar et al. (2012) conducted one of the earliest studies on Strategic Carbon Management (SCM) in organisations and HEIs. They concluded that there is a wealth of information in the literature on CMPs for the public sector, particularly on the topics of carbon plans and their implementation. However, there is a lack of academic literature on integrating carbon plans with the organisation's strategic objectives. The authors also observed that there is no distinction between carbon management and strategic carbon management. Identifying SCM as a separate topic is essential for integrating the carbon plan into the organisation's strategy.

Robinson (2017) conducted a qualitative comparative study on UK HEIs to understand the following issues:

- Study the disparity in carbon management standards across HEIs.
- Investigate how these standards are interpreted.
- Propose a universal method for carbon planning.

- Tackle the data problem.

Robinson (2017) also studied the current state of carbon measurement and reporting techniques in UK HEIs. The author noted that while HEIs calculate scope 1 and 2 emissions, they do not calculate or report scope 3 emissions. HEIs widely report emissions from stationary combustions, imported energy, and waste. The author has also divided the carbon management of the University into three parts:

- Scoping: This involves setting a boundary and identifying the organisation's actions and activities.
- Conceptualising: This involves collecting data and applying the carbon equation.
- Communication: This involves producing a carbon report.

Altans (2010) surveyed the UK HEIs to learn more about the effectiveness of the HEIs' internal carbon reduction intervention. The technical, non-technical, and management interventions used by HEIs to minimize emissions were covered in the survey's questions. According to the report, replacing boilers was the most frequent technological intervention made by HEIs, followed by installing control systems and submeters. However, when it came to HEIs' preference, equipment replacement and improvement were ranked 4 out of 7. According to Mendoza et al. (2019), the majority of organisations, including HEIs, do not adhere to strict circular economy (C.E.) principles. The main reason for not implementing C.E. in HEI is the lack of a credible business case. The authors of this study address this issue using the C.E. framework of back casting and eco-design for Circular Economy (BECE), which consists of exploration, assessment, and reflection used to assess and prioritize C.E. solutions. The authors conclude that the HEIs can play a pivotal role in the development and practice of C.E., thereby propagating its concepts and benefits to its suppliers and broader society. Mazhar (2014) conducted an inductive and exploratory study in which the authors interviewed several stakeholders responsible for carbon management in HEIs. The study identified that the estates' department is primarily responsible for HEIs carbon management. Primary stakeholders are motivated to meet the carbon reduction objectives, but they face several internal and external challenges like:

- Lack of direct link between the carbon management plan and the strategic objective of the University
- Ambiguity in the understanding between carbon management and sustainability
- The resource for carbon reduction, primary energy consumption, is allocated by top management
- How to tackle absolute targets when the University is expanding every year.

- Lack of understanding of how to calculate scope 3 emissions

2.2 Emission scopes

The method, location, and person who calculates carbon emissions all affect the results. The literature now available demonstrates that the three approaches used to calculate emissions are territorial-based emissions, production-based emissions, and consumption-based emissions. Due to its simplicity and lack of ambiguity, production-based emissions calculations are used by the majority of nations. This is because consumer-based emissions account for all carbon emissions caused by national or regional acts, governments have just begun to adapt to them (Peters and Hertwich, 2008; Olivier and Peters, 1999; Wyckoff & Roop, 1994; Imura & Moriguchi, 1995; Lenzen et al. 2004).

The methodologies which the organisation widely uses to report the emissions are as follows:

- ISO 14064:2006 GHGs-Part 1 and 3 (ISO 2006a, b) and ISO/WD TR 14069 working draft 2 (2010)
- Greenhouse Gas Protocol Corporate Accounting and Reporting Standard (WRI and WBCSD 2004, 2011)
- Bilan Carbone (version 5.0; ADEME 2007)
- DEFRA (2009)
- CDP Water Disclosure (CDP 2010)
- Global Reporting Initiative (version 3.0; GRI 2006)

The Greenhouse Gas Protocol (2004) is a widely used for measuring and reporting emissions in the literature. There are three categories for emissions: scope 1, scope 2, and scope 3, which are explained in section 1.1. (Global Warming Potential Protocol, 2004, Bhatia et al., 2011)
According to the GHG Protocol (2004) and Robinson et al (2015), the computation of these emissions are objective. On the other hand, the computation of scope 3 emissions is not simple due to the ambiguity around the emissions cut-off and the difficulty in obtaining third-party data. Organisations disregard scope 3 emissions because of methodological complexity, data scarcity, a lack of drive, and technical know-how. On average, scope 3 emissions comprise nearly 75% of the organisation's total emissions (Huang et al., 2009). Since most emissions are outside the organisation's control, any organisational climate change strategy will be ineffective without a complete understanding of scope 3 emissions (Matthews and

colleagues, 2008). Therefore, the union of scope 1, 2, and 3 emissions can give the entire emission liability of the organisation.

2.3 Scope 3 emissions

Despite the importance of overall emissions, minimal research is carried out on scope 3 emissions in general and scope 3 emissions in particular for HEI. Moreover, the reporting of scope 3 emissions is non-voluntary, making it easy for the organisation to avoid this responsibility (Pelletier et al., 2014). Matthews et al. (2008) stated that, on average, the scope 1 emission is just 14% of the total carbon footprint. Scope 1 & 2 emissions are 26% of the total emissions. Still, more than half the carbon footprint is unaccounted for. Hertwich and Wood (2018) studied the growing importance of scope 3 emissions in industries and regions. The author conducted a study to estimate indirect emissions in 5 different sectors – energy supply, transport, industry, buildings, agriculture, and forestry. The result showed that the building's indirect emissions were twice as high as direct emissions, which is also corroborated by Matthews et al. (2008). Downie and Stubbs (2013) analyzed the scope 3 methodologies generally used by organisations in Australia. The authors reported a wide variation in the methodologies and results among the organisations. The authors stated that the number of activities reported within the scope of emissions varied significantly among the organisations. As a result, the scope 3 emissions as a percentage of total emissions also varied to a large extent. This exercise demonstrated a significant inconsistency in the scope 3 emissions methods.Determining boundaries for the different scopes is critical, or there is a danger of double counting. Double counting is a phenomenon where a particular emission is accounted for in two different scopes. The wide disparity in the scope 3 emission is also because of no clarity in defining boundaries for scope 3 emissions.

For broader adoption of scope 3 emissions, further refinement in the methodology is required (Hoffmann and Busch, (2008); Busch (2010); Huang et al. (2009)). To overcome the inconsistencies in scope 3 emissions, Li et al. (2019) developed a new upstream emission footprint indicator. The author aimed to identify the ideal scope 3 emissions trajectory for a given sector in a country. Though this study is helpful for a region or country, it does not help small nation, organisations or HEIs.

2.4 Scope 3 emissions calculation in higher education institute

This section of the literature review (2.4) comprises a systematic review and a meta-analysis. The study focused on the topic of "Scope 3 emissions in Universities," and the search term used was precisely that. The search results yielded a combination of academic studies, white papers, and University reports. To ensure thorough coverage, both Google Scholar and general search engines were utilized in the literature search. Inclusion criteria for selecting literature were stringent, with only "complete" works meeting the study's requirements considered. These included studies that provided a detailed description of Scope 3 emission calculations and their breakdown, following the GHG Protocol (2009) guidelines. The analysis placed specific attention on the data quality, the methodology employed, the inclusion of emission activities within scope 3 emissions, and the methods used to account for these activities.

Out of the search results, a total of nine relevant works of literature were identified, all of which met the criteria for the current study. Among these, five were academic studies, and the remaining four were University reports. Geographically, the literature covered multiple regions, with three studies from North America, two from the United Kingdom, two from Chile (from the same University but different years and authors), and one each from Canada and Malaysia.

Table 2-1: Literature with HEI scope 3 emissions

No	Literature	Academic/ Report	University	Country	Scope
1	Vásquez et al. (2015)	Academic	University of Talca	Chilli	1,2,3
2	Yañez et al. (2019)	Academic	University of Talca	Chilli	1,2,3
3	Thurston and Eckelman (2011)	Academic	Yale University	North America	3
4	Bazylak et al. (2020)	Report	University of Toronto	Canada	3
5	Landesberg and Brady (2014)	Report	University of Richmond	North America	3
6	Klein-Banai and Theis (2013)	Academic	USA education institute	North America	1,2,3
7	Yusoff et al. (2021)	Academic	University of Malai	Malaysia	3
8	Htet et al. (2018)	Report	University of Worcester	United Kingdom	1,2,3
9	AECOMM (2014)	Report	Cambridge University	United Kingdom	3

Table 2-2: : Coverage of different scope 3 emissions in literature

Scope 3 Components	Vásquez et al. (2015)	Yañez et al. (2019)	Thurston and Eckelman (2011)	Bazylak et al. (2020)	Klein-Banai and Theis (2013)	Yusoff et al. (2021)	AECOMM (2014)	Thein et al. (2018)
Water Supply	**No**	**No**	**No**	**No**	**No**	**No**	**Yes**	**Yes**
Water waste treatment	**No**	**No**	**No**	**No**	**No**	**No**	**Yes**	**Yes**
Water collection and management	**No**	**No**	**No**	**No**	**No**	**No**	**Yes**	**Yes**
Transport-Commuting	**Yes**	**Yes**	**No**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Transport-Business	**Yes**	**Yes**	**No**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Procurement	**No**	**Yes**	**Yes**	**No**	**No**	**No**	**Yes**	**Yes**
Upstream	**No**	**No**	**No**	**No**	**No**	**No**	**Yes**	**Yes**
Solid waste	**No**	**Yes**	**No**	**No**	**Yes**	**No**	**?**	**?**

Table 2.1 indicates that the existing literature studied only 7 of 15 emission sources described in the GHG protocol scope 3 guidance. The emission activity studied in the literature were: water supply, water waste treatment, water collection and management, transport commuting, transport business, procurement, and upstream emissions.

In the literature, the reasons for selecting specific emission activities varied among the authors. For instance, Vásquez et al. (2015) did not provide any explicit justification for their choice of emission activities. On the other hand, a subsequent study conducted by the same Higher Education Institution (HEI) by Yañez et al. (2019) identified the reasons behind their selection. Yañez et al. (2019) stated several reasons for choosing the particular set of emission activities. These reasons included contribution to total emissions, representation within the organisation, emission activities, data availability, stakeholder's interest, potential for reduction. The discussion section of the study also addressed the trade-off between completeness and data relevance. This highlights the careful consideration of including emission activities that are both comprehensive in coverage while being relevant to the specific context of the HEI. By providing clear reasons for their selection of emission activities, Yañez et al. (2019) demonstrated a thoughtful and rationale-driven approach to evaluating scope 3 emissions, enhancing the overall robustness and relevance of their findings.

The contribution of the activities that lead to scope 3 emissions is an essential point to consider while shortlisting the emission activity data because there is no point in investing time where the emissions forms a minor component of the overall emissions. Vice-versa, HEIs doesn't want to miss out on any significant emission component due to false assumptions. In addition, it is also challenging to determine the contribution of the emissions activity beforehand because each organisation is different, and only an experimental study can help determine the proportion of emissions from each activity. This strategy was used by Thurston and Eckelman (2011) in cases when the author lacked prior knowledge of the emissions from purchasing activity. The author conducted pilot research to quantify the emissions resulting from the purchase of coke and glass to determine the extent of emissions caused by Yale University's purchasing activities. After observing the significant contribution from the pilot study, the authors recommended scaling up the study to include all the purchasing activity. Purchasing-related emissions can vary greatly based on the type of the institute. For instance, an HEI with hospital chemistry/physics labs and a lot of materials will produce more emissions than one with simple classroom instruction in subjects like law or humanities (Baboulet and Lenzen, 2010). The inclusion of emissions from purchasing operations by science institutes is therefore reasonable. HEIs that lack a scientific background or use less material can carry out an experimental investigation to comprehend the scope of emission. Yusoff et al. (2021) adopted this approach, and it was observed that scope 2 emissions were higher than the benchmark because of intensive laboratory work. Klein-Banai and Theis (2013) analysed emissions from the North American education institutes. The North American education institute follows the ACUPCC (2012) guideline for estimating emissions.

Based on HEFCE guidelines, the HEIs must provide scope 1 and scope 2 emissions, consisting of sites purchased electricity and emissions from the site's stationary and moving emission source Ward et al. (2008) conducted a correlation analysis between energy consumption and other HEI-dependent factors. The current study differs from Ward et al. (2008) in several manners, for example, this study focuses on Scope 1, 2, and Scope 3 emissions versus several important factors described in chapter 4. This study goes well beyond the factor analysis and explores the complexities of the scope 3 emissions and develop system to estimate HEI scope 3 emissions.

Several interesting research studies have explored scope 3 emissions in various contexts. While these studies may not have employed in-depth methodologies, they have presented intriguing statistics. For instance, Hoolohan et al. (2021) conducted a qualitative study examining scope 3 emissions from travel and catering services at 66 UK universities. The authors concluded that air transportation is the primary mode of university travel, associated with the highest emission factor. They also found that although universities are aware of their contribution to air travel demand, they lack systems and incentives to record air travel emissions. The University of Exeter estimated that food procurement emissions constitute approximately 15% of total procurement emissions, which represents around 61% of the university's overall emissions. Similarly, the Technical University of Pereira estimated scope 1, 2, and 3 emissions for 2017. The results indicated that 97% of the total emissions were classified as scope 3 emissions. Among these, student commute accounted for 77%, infrastructure construction contributed 10.4%, and staff commute contributed 4.4% (Varón-Hoyos et al., 2021). Herth and Blok (2023) also quantified scope 1, 2, and 3 emissions, including those from procurement and catering. They employed process life cycle assessment (LCA) whenever activity data was available and utilised the extended input-output analysis methodology when appropriate data was lacking. The findings revealed that scope 1 and 2 emissions accounted for 17% of the total emissions, with the remaining emissions attributed to scope 3.

In 2018, the University of Southampton emitted 129,600 tCO_2e, with 80.6% stemming from scope 3 emissions (Ben, 2021). However, the methodology for this particular study was not provided.

Helmers et al. (2021) analysed emissions calculations from 20 HEIs worldwide. As these HEIs were geographically diverse, the emissions patterns varied significantly. For example, some HEIs in the USA had their own energy generation systems, altering the emissions profile. Mobility emissions were found to be the largest contributor within scope 3 emissions for all HEIs. None of the HEIs reported emissions from procurement. In summary, various research studies have examined scope 3 emissions, providing insights into different aspects such as travel, catering, and procurement. These studies shed light on the potential for emissions reduction by making changes to food choices, transportation modes, and energy generation practices within HEI campuses.

The existing literature reveals a limited number of studies focusing on the drivers of emissions in UK HEIs, as well as understanding the trends, patterns, and reporting structures of emissions across the three scopes. The literature review underscores that scope 3 emissions are the primary contributors to emissions in HEIs, ranging from 40% to 90%. Furthermore, the activities included in the calculation of scope 3 emissions exhibit significant variations among HEIs and countries. Commonly recorded activities include electricity grid transmission and distribution, recycling, waste management, and water transmission and distribution. While many HEIs attempt to calculate travel-related emissions, comprehensive calculations in this area are lacking. Very few HEIs have addressed emissions related to procurement and catering, which constitute a substantial component of the total emissions. Moreover, there is a dearth of literature providing a clear methodology for estimating different scope 3 emissions. Additionally, it is important to note that no studies have compared scope 3 emissions specifically within the UK or its regions (Scotland, England, and Wales). Therefore, this study aims to analyze scope 3 emissions, evaluate the inclusion and exclusion of emission activities, examine the reporting structure of emissions activities, and benchmark HEIs in terms of their emissions performance.

2.5 Knowledge gaps

The research question was built on the foundation of the two works of literature which are Hertwich & Wood (2018) and Huang et al. (2018). Scope 1 & 2 has been studied extensively since the inception of the GHG protocol, on the other hand, scope 3 studies are fragmented and non-comprehensive. The literature review has shown that the measurement of indirect emissions are essential, but limited research is done on it. Especially for the HEIs, indirect emission study is minimal, as shown in Tables 2-1 & 2-2. The two main issues that make measuring scope 3 emissions challenging are the problem of double counting and boundary conditions. If these complexities are addressed, it may be possible to make scope 3 reporting mandatory. In addition, Table 2-1 &2-2 shows that the critical scope 3 emissions sources are travel, procurement, commuting, electricity upstream, and water supply and transport. No literature examines how the HEIs report these sources of emissions and how that affects the overall emissions. Moreover, demonstrating a comprehensive methodology to estimate the HEI scope 3 emission and benchmarking quality of scope 3 emissions reporting can go a long way in streamlining this activity. The COVID lockdown is a very recent phenomenon and its impact on emissions are hardly studied. It will be interesting to understand how the COVID lockdown impact the HEI emissions.

This study aims to bridge all the above gaps by studying scope 3 emission patterns for HEIs. To narrow down the study, only Scottish HEIs are reviewed. The study identifies the difficulties faced by the HEI while reporting scope 3 emissions, and also compares the HEIs based on the quality of their reports and knowledge of scope 3 emissions. To re-estimate scope 3 emissions, based on benchmarking and best practices, a case study of RGU has been used.

3. Methodology

3.1 Knowledge gap

This research began with a literature review on emissions in general, exploring the existing knowledge in the scope 1, 2, and 3 emission space. The literature review found that the estimation of scope 1 and scope 2 emissions is more straightforward than scope 3. Hertwich & Wood (2018) and Huang et al. (2018) emphasised the importance of assessing scope 3 emissions, concluding that over 75% of an organisation's carbon footprint is categorised in scope 3. Many organisations either report a portion of their scope 3 emissions or disregard them altogether because it is difficult to assess these emissions. The research question was built on the foundation of these two works of literature. The overall literature review suggests that although it is difficult to quantify scope 3 emissions, it is essential to calculate them. While a few organisations have partially figured this out, there are many more estimates and assumptions involved in the calculations. The difficulty of determining scope 3 emissions was found to be a significant knowledge gap. The case study of UK HEIs helps to further close this knowledge gap. Since there are more than 150 HEIs in the UK, a thorough analysis would take a long time and be very difficult. The study was subsequently limited to seventeen Scottish HEIs.

The research objectives, as described in chapter 1 are as follows:

1. Exploratory data analysis of scopes 1, 2 & 3
2. Scottish HEI scope 3 reporting analysis
3. Estimating scope 3 emissions for RGU
4. Benchmarking of the Scottish HEI based on their scope 3 emissions reporting
5. Impact of COVID

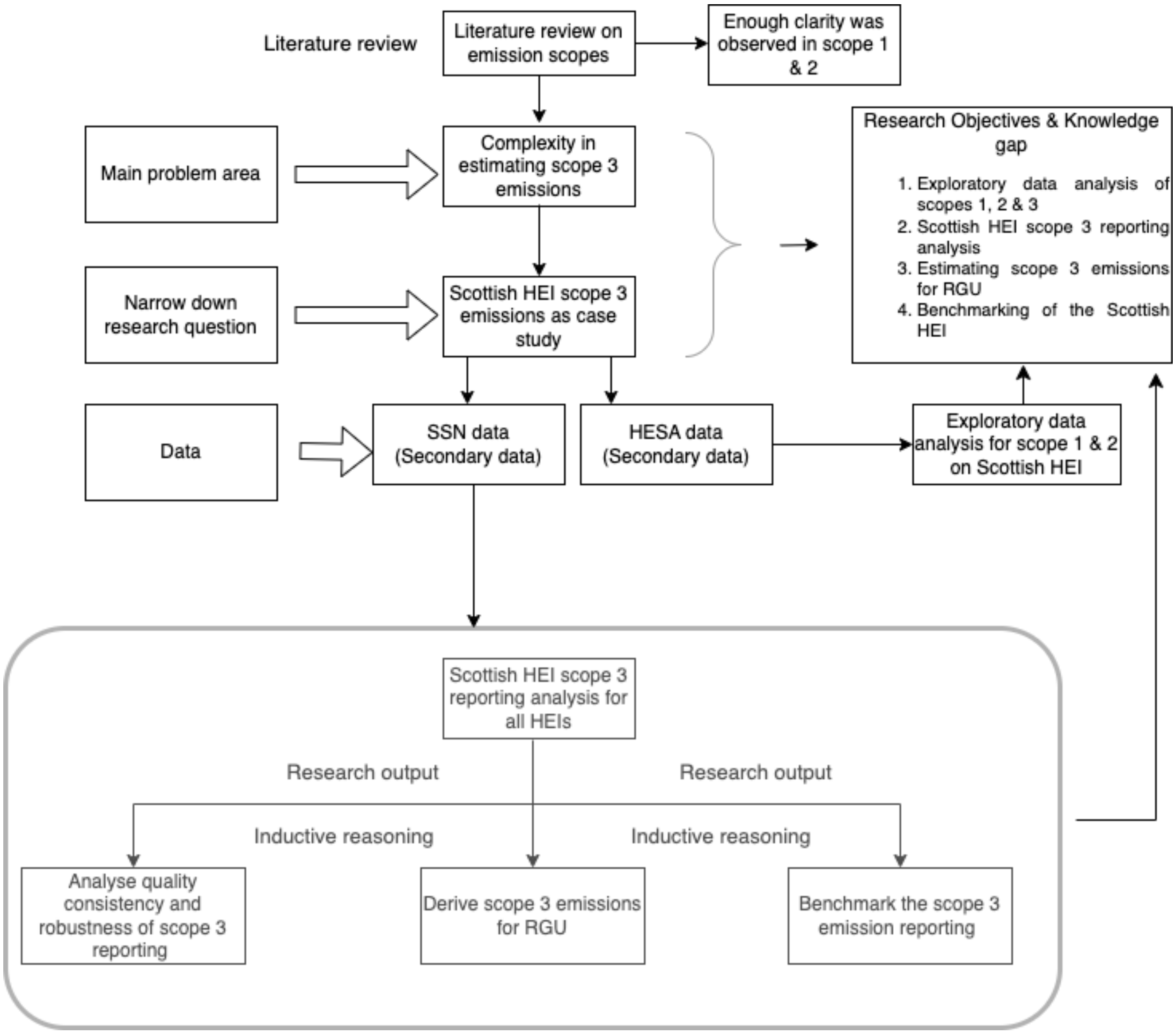


Figure 3-1: Research process and design

3.2 Data

According to the literature review, UK HEI data is available on the HESA website. The open data component of HESA includes information on students, employees, graduates, finances, business community involvement, estates management, the archive of publications for UK performance indicators, and research. The data for this research was derived from the student, staff, and estate management sections. Within estates management, there are the following subsections: buildings/spaces, energy, emissions/waste, transport/environment, and finances/people. The data content of each section is described below.

Students:

This section provides data on the number of students, where they study, what they learn, their domicile, accommodation, progression, and other personal characteristics.

Staff:

This section provides data on the number of staff, their breakdown based on full-time, part-time, research/teaching, demographic detail, employment conditions, salaries, and domicile.

Estates management:

This section provides data on geographic aspects such as internal area, number of buildings, and parking breakdown. The energy section contains data on water use and renewable energy sources in addition to data on energy usage. The section on emissions and waste has data on HEI scope 1, 2, and 3 emissions. It has the HEI-wise aggregate data for scopes 1, 2, and 3, and emissions data breakdown is lacking. Estate management also records the HEI parking area breakdown, HEI budget, expenditure on research and teaching, and people stats (staff and students).

The oldest data is from 2015-2016, and the data-sets are updated annually. They are regarded as secondary data because they were collected and provided to the HESA by the specific HEI.

3.2.1 Calculation of Carbon Dioxide equivalent (CO2e)

Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases (hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen trifluoride) can trap heat and increase global temperatures. These gases are also known as GHGs (GHGs), and their unique effects on the environment vary. The environmental impact of each gas is known as its global warming potential (GWP), with CO_2 having a GWP of 1. GWP is also measured over time. For example, five years of CH_4 in the atmosphere will have a different impact than ten years of CH_4 in the atmosphere. In general, GWP is calculated over 100 years and is represented as GWP100. The impact of all GHGs is combined and expressed as carbon dioxide equivalent (CO_2e). CO_2e is calculated using the following formula:

$$CO_2e = \sum GHG_i * GWP_i - - - -EQ - 3.1$$

$$Where\ i\ is\ the\ ith\ GHG\ in\ weight\ (Kgs\ /\ tones\ )$$

The GWP for each GHG is described in EPA (2022). TheGWP_{100} of CH4 is 30, GWP_{100} Of N2O is 273, and fluorinate gasses are in the tens of thousands. The carbon emission is estimated using the equation below:

$$CO2 = Activity\ data * Emission\ factor - - - -EQ - 3.2$$

Direct access to Scope 1 & 2 emission data is provided on the HESA portal. The HESA website does not provide discrete activity data.

Another data source where each Scottish HEI submits its thorough emission estimations is Sustainable Scotland Network (SSN). The EF and activity data make up the data set. The budget, target emissions, sustainability strategy, and historical scopes 1, 2, and 3 emissions statistics are also included. The SSN data is available from 2015 to 2021 for each Scottish HEI academic year. This data is updated yearly with a few months of lag. This thesis primarily utilizes the SSN data for calculation purposes, wherever SSN data is incomplete, it is complemented by HESA data.

3.3 Methodology and calculations

The thesis starts with exploratory data analysis on scopes 1 and 2 for UK HEI, where the data is sourced from HESA. This section collects data on people, areas, waste, finances, students, and staff for UK HEIs. All the HESA-provided variables are correlated to the emissions in a correlation study. The coorelation among the variables are studied because it can give insight on the variable relationship, variable selection, quality of data and to identify test hypothesis. Between the dependent and independent components, a linear relationship is presumed. In the formula below, the Pearson correlation is applied because it gives an easy interpretation of the degree of association between the variables and it is easy to understand. Inaddition it is scale agnostic therefore any two continuous variable can be compared. The formula for pearson coorelation cooefficient is as shown below.

$$\rho_{x,y} = \frac{cov(X,Y)}{\rho_x \rho_y} - - - - - EQ - 3.3$$

Where, $\rho_{x,y}$ is the correlation coefficient between X (independent variable) and Y (dependent variable). The correlation coefficient varies between the value of -1 to +1.

- There is no association between the variables if the correlation coefficient is 0.
- A positive correlation between two variables exists if the correlation coefficient is 1. In this case, as the independent variable increases, the dependent variable also increases.
- A negative correlation exists between the variables if the correlation coefficient is -1. In this case, the dependent variable decreases as the independent variable increases.

For this thesis, a correlation coefficient greater than absolute 0.65 is considered a good correlation, a high correlation does not, however, prove that the independent variable is what drives the dependent variables. To determine the reason for the coorelation between the independent and the dependent variables, more analysis, research, and hypothesis testing are needed.
The data of 17 Scottish HEIs are used to do the explolatory data analysis. Nevertheless, their sizes and modes of operation differ greatly. The size of the HEI can be determined by looking at its internal area, budget, or student population for comparison's sake, for instance, the RGU, and GCU (Glasgow Caledonion University) are modern universities with concentrated campuses, but the University of Edinburgh and University of Aberdeen are historic universities spread out across a larger territory. They have expertise in different subject areas, and the focus on research varies. Because of the various scales, comparing these HEIs directly does not provide a clear picture. Data normalisation is a widely used method for comparing data on various scales. The widely used normalisation techniques are:
The data derived from various HEIs exhibit differences in scale and magnitude. For instance, the University of Edinburgh surpasses Robert Gordon University in terms of physical space and student population by more than two-fold. Consequently, the energy consumption at the University of Edinburgh is expected to be higher compared to that of Robert Gordon University. To enable a meaningful comparison of energy consumption performance, it is crucial to normalise and scale from both HEIs appropriately.

In this thesis, the emissions are compared with several factors such as the budget, number of students, internal area, and staff, which drive the emissions. Wherever a comparison is required, emissions and budget are normalised. The time series normalised values are then compared among the HEI or within the HEI. Lets consider a case where the student Full Time Equivalent (FTE) and scope 3 emissions are compared. In this scenario, the student FTE is divided by the emissions to get emissions per student. Regardless of how an HEI operates or how big it is, emissions per student offers a clear picture of its emission scale. One disadvantage of this technique is that the normalised value may not show an accurate picture when comparing a very small and a very large HEI. For example, if an HEI has 100 students, it would need a minimum infrastructure to operate the 100 students, leading to higher student emissions. Whereas if the HEI has 20,000 students, then the scale of the operation can lower the per-student emissions. Therefore, it may not be comparable in extreme cases. In this thesis, no such high variation among the HEIs was observed.

3.3.1 RGU emission derivation

RGU has reported only a limited amount of data regarding its emissions, so its scope 3 emissions are determined using information and calculations provided by other Scottish HEIs. To derive RGU's scope 3 emissions, it is essential to identify an HEI that is similar to RGU in terms of operation, subject, budget, research, foundation year, and demography. HESA data was used to compare RGU with different Scottish HEIs. The peer identification process began with the foundation year. Initial research revealed that HEIs founded several centuries ago are very different from contemporary HEIs. The following comparison factors were analyzed: budget, number of students, and staff. Since there are a limited number of HEIs in Scotland, the closest match is considered a peer. There may not be many characteristics where the closest matched peer and RGU differ significantly. The analysis starts with the identification of most scope 3 intensive activity. The Scottish HEI data indicated the following scope 3 emissions activities:

- **Procurement:** Only St Andrews University reported procurement for a couple of years. The reported values were an estimate rather than derived values. Since no primary or secondary data is available, the procurement emission is derived from the statistics presented in the past literature, which has stated the procurement emission as a percentage of the total and scope 3 emissions. The secondary data from the previous two studies were used to develop this quantitative analysis. Since each HEI is unique and has different procurement needs, the value obtained using this method does not have a high degree of confidence. Nevertheless, this is the only data available that can be used for derivation.

- **Student international travel:** GCU is the only HEI that has calculated the students' international trip emissions. HESA has the domicile data alongside the origin country. The country's capital city's aircraft travel distance is estimated, and the EF is derived using the DEFRA conversion factor. In each academic year, it is assumed that students will make one trip home. Equation 3.2 is used to calculate emissions, using the activity data from HESA and the EF coming from DEFRA. Since the data is complete, high quality, and updated frequently, the emissions derived from this methodology are of high confidence.

- **Student commute:** The student commuting emissions are derived by comparing the peer HEI student commute data. The student FTE is used to normalize the peer HEI commute emission. The RGU student commute is estimated using the peer normalised value against the emissions. When a peer HEI has 100 students and a commute emission of 1000 tCO2e, for instance, then the normalised student emission is 10 tCO2e/student. The number of students FTE is known for RGU. The student commute emissions can be derived by multiplying the normalised student emissions by the number of students.

- **Staff commute:** The same methodology is used as in the student commute emissions.

- **Business travel:** RGU has calculated the business travel emissions from its primary data

- **Grid T&D:** RGU has calculated the grid T&D from the primary data

- **Water S&T:** RGU has calculated its water S&T emissions from its primary data

- **Recycling and waste**: RGU has calculated the recycling and waste emissions from its preliminary data.

The above calculation results in RGU's scope 3 emissions for each emissions source. The emissions are calculated for each year from 2016 to 2021. The impact of each emissions source is also estimated by calculating its percentage share of the total emissions. The contribution of each emissions source to scope 3 emissions is determined over four years, and the four-year mean is calculated. The weight of the emissions source within scope 3 emissions is determined by using the mean value.

3.3.2 Benchmarking

Benchmarking indicates the relative performance of the Scottish HEIs. The HEIs are benchmarked against their reporting quality. The reporting quality consists of data quality, completeness, and consistency. The benchmarking is carried out using the generic equation:

$$b = \frac{\sum w_i * s}{\sum w_i} - - - - EQ - 3.7$$

$$wi \text{ is the weight given to the each emission source}$$

$$s \text{ is the score given to the data of the emission source}$$

$$b \text{ is the benchmarking score}$$

This question is further modified to incorporate the specific case of the Scottish HEI. The detailed method and example are shown in section 5.6.1. The approach, design, and step-by-step research process were all discussed in this section. A comprehensive view of the full thesis framework is provided in Figure 3.1. The next is the results chapter that contains the summary of the major findings.

The scope of work for this thesis is outlined as follows:

- Acquisition of emissions-related data for Scottish HEIs from the HESA and SSN.
- Conducting exploratory data analysis on the comprehensive dataset collected in Step 1. The objective is to identify the primary factors driving emissions for Scottish HEIs, encompassing scope 1, 2, and 3 emissions.
- Performing a detailed analysis of scope 3 emissions reporting specifically for Scottish HEIs. Each entry is meticulously analyzed and compared with peer institutions. Scope 1 and 2 emissions are not considered in this particular study.
- Deriving best practices based on the reporting structure of scope 3 emissions and utilizing this information to calculate scope 3 emissions for Robert Gordon University in the year 2019.

- Employing a novel algorithm to benchmark HEIs by considering the quality, consistency, and completeness of data. This benchmarking process is exclusively conducted for scope 3 emissions and excludes scope 1 and 2 emissions.
- Analysing the impact of the COVID-19 pandemic on scope 3 emissions by comparing emissions during lockdown periods with emissions during unaffected periods. This analysis pertains solely to scope 3 emissions.

4. Explolatory data analysis- Scope 1,2 & 3

This chapter undertakes an exploratory data analysis of scope 1, 2, and 3 emissions from UK HEIs. This is a very high-level preliminary study to understand the emissions profile of HEIs. Various drivers are considered, and their relationship with emissions is estimated using normalisation and correlation analysis.

4.1 Scope 1 & 2 emissions

This section shows the aggregate result for HEIs scope 1 &2 emissions. Scope 1& 2 studies on individual HEIs are excluded, whereas scope 3 is included. The data is available from the estate's management of the HEFCE (HEFCE, 2020) in the following categories:

1. Building and spaces
    - Total number of sites
    - Total number of buildings
    - Total site area (hectares)
    - Total grounds area (hectares)
    - Total playing fields area (hectares)
    - Total gross internal area (m^2)
    - Total number of car parking spaces
    - Total number of cycle spaces
2. Emissions and waste
    - Total scope 1 and 2 carbon emissions (Kg CO_2e)
    - Total volume of wastewater (m^3)
    - Total scope 3 carbon emissions from waste (tonnes CO_2e)
    - Total scope 3 carbon emissions from water supply (tonnes CO_2e)
    - Total scope 3 carbon emissions from wastewater treatment (tonnes CO_2e)
    - Total waste mass (tonnes)
3. Energy
    - Total energy consumption (kWh)
    - Total fuel used in HE provider-owned vehicles (litres)

- Total generation of electricity exported to the grid (kWh)
- Total water consumption (m3)
- Total renewable energy generated onsite or offsite (kWh)

4. Finance and people
    - Total income (£)
    - Teaching income (£)
    - Research income (£)
    - Other non-residential income (£)
    - Non-residential income total (£)
    - Total expenditure (£)
    - Teaching student headcount
    - Research student headcount
    - Teaching student FTE
    - Research student FTE
    - Total staff FTE

The following section analyses each of the above factors in detail.

4.1.1. Building and spaces

The dataset regarding buildings and spaces encompasses information pertaining to seven factors. Table 4-1 displays the correlation between scope 1 and 2 emissions and the buildings and spaces variables. On the other hand, Table 4.2 presents the normalised values of scopes 1 and 2 in relation to the buildings and spaces data. An analysis of the past five years reveals consistent and strong correlations (greater than 0.6) between total number of buildings, total playing field area, total gross internal area, and total number of cycle spaces with scopes 1 and 2 emissions. Notably, the most significant improvement during this period is observed in emissions per cycle space, which has reduced from 18,148 Kg CO2e emissions per cycle space in 2014–15 to 10,362 Kg CO2e emissions per cycle space in 2018–19.

Furthermore, there has been a noteworthy 33% improvement in emissions per gross internal area over the past five years. Although emissions per site have shown a minor improvement, it is not as substantial as the aforementioned factors.

Table 4-1 Correlation analysis for building and spaces versus scope 1 & 2 emissions

Factors	2014-15	2015-16	2016-17	2017-18	2018-19
Total number of sites	0.46	0.23	0.25	0.25	0.42
Total number of buildings	0.74	0.67	0.74	0.72	0.72
Total site area (hectares)	0.53	0.36	0.61	0.57	0.50
Total grounds area (hectares)	0.5	0.54	0.55	0.52	0.48
Total playing fields area (hectares)	0.64	0.71	0.71	0.7	0.63
Total gross internal area (m2)	0.96	0.95	0.96	0.95	0.96
Total number of car parking spaces	0.57	0.57	0.6	0.6	0.6
Total number of cycle spaces	0.76	0.76	0.75	0.75	0.75

Table 4-2 Ratio analysis for building and spaces versus scope 1 & 2 emissions

Scope 1& 2 emission Kg CO_2e	2014-15	2015-16	2016-17	2017-18	2018-19	Improvement
Emissions per site	29,67,359	27,47,253	25,90,674	23,36,449	23,80,952	19%
Emissions per buildings	1,41,843	1,27,713	1,22,249	1,09,649	99,009	30%
Emissions per site area (hectares)	2,10,084	1,87,970	1,72,117	1,57,729	1,31,926	37%
Emissions per grounds area (hectares)	3,37,838	3,00,300	2,69,542	2,49,376	1,93,423	43%
Emissions per playing fields area (hectares)	13,58,696	12,18,026	12,31,527	11,56,069	10,33,057	24%
Emissions per gross internal area (m2)	81.68	72.7	67.74	60.86	54.8	33%
Emissions per car parking spaces	11,918	11,160	10,395	9,438	8,555	28%
Emissions per cycle spaces	18,148	16,806	14,430	12,391	10,362	43%

Figure 4-1 shows the relationship between the site's internal area versus the car and cycling space. The general notion is that as the site area increases, the HEI can increase the cycling space and restrict the car parking space.

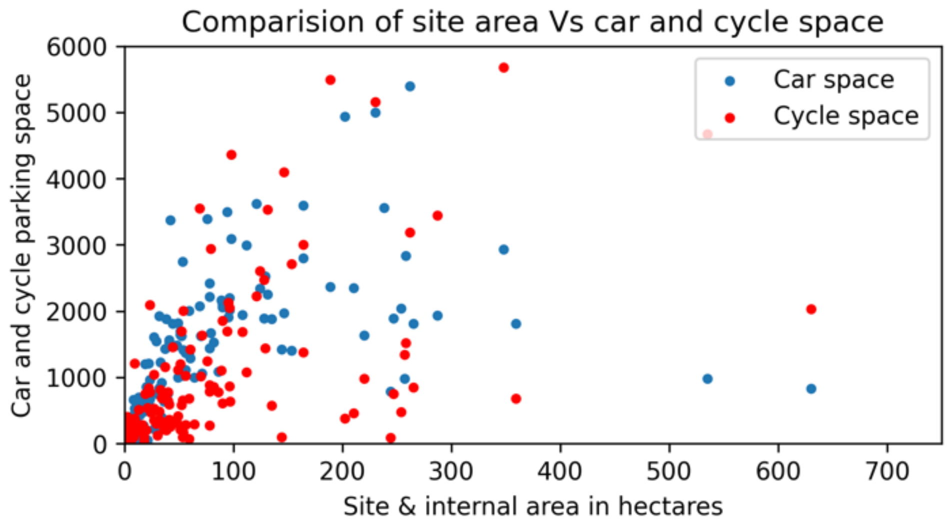


Figure 4-1 : 2018-19- The scatter plot showing the relationship between the internal area against the car and cycle space available in the HEI

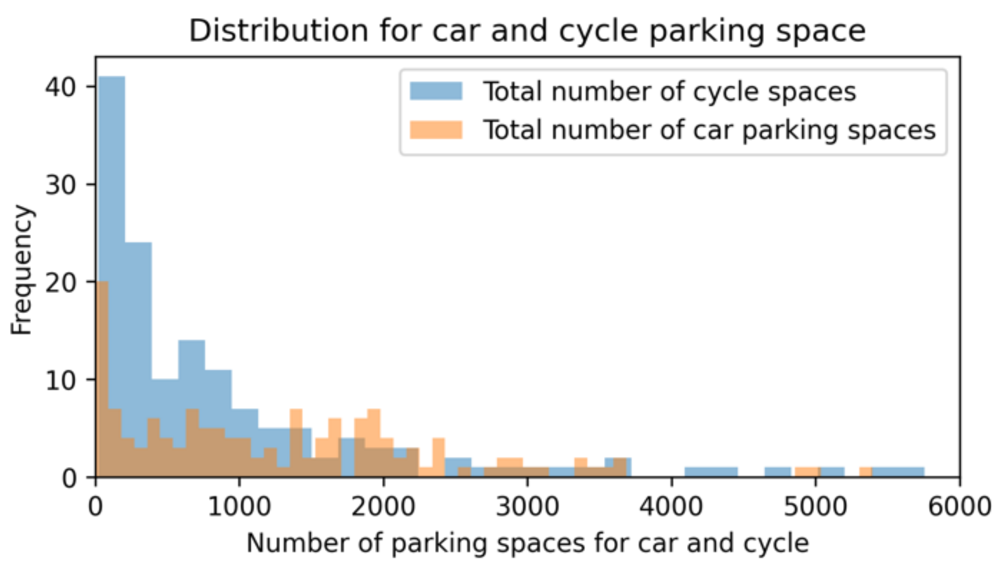


Figure 4-2 : The distribution plot of the cycle and the car space across the HEI. 2018-19

Figure 4-1 also shows that as the internal site area increases, the car and cycle space increases but only up to 100 hectares of internal site area and 2000 spaces, after which the relationship fades out. The car space's growth rate versus the internal area is higher than the cycle space versus the internal area.

The distribution figure 4-2, which shows the car and cycle space distribution for 2018-19, also complements this relation. The aggregate summary statistics for last five years are as follows:

- The aggregate car parking space has decreased by 5%
- The aggregate cycle space increased by 15%
- The aggregate emissions were reduced by 39%
- Emission per car parking space has been reduced by 28%
- Emissions per cycle space have been reduced by 43%

The available data suggests that car usage remains highly prevalent and has not been sufficiently reduced to have a significant impact on emissions. Ideally, there should be an increase in emissions per car space, indicating that the emissions are significantly lower than the number of car parking spaces available. If the reduction in the number of car spaces outpaces the decrease in emissions, then the emission per car park will either remain the same or increase. Moreover, over the previous five years, there has been a 43% decrease in emissions per cycle space. However, it is important to note that this improvement in emissions per cycle space is primarily driven by a 15% reduction in emissions, rather than a substantial increase in cycle space. This is evident from the fact that the increase in cycle space is only 15%. Among other factors, there are promising improvements in emissions per grounds area and emissions per gross internal area.

4.1.2 Energy

Energy and water consumption are the only factors that correlate with scope 1&2 emissions. Other factors have a very low correlation coefficient. Ward et al. (2008) also highlighted the high correlation between energy consumption and emissions. The distribution plot for the energy and water usage for 2018–19 is shown in Figures 4-3 and 4-4 The distribution plot illustrates that the majority of HEIs consume less than 50,000 GWh of energy. However, a few HEIs exhibit higher energy consumption, surpassing 200,000 GWh. Notably, these HEIs with elevated energy consumption tend to have larger internal areas and a higher number of students. Similarly, when considering water consumption, the range varies from a few thousand cubic meters to 700,000 cubic meters. Similar to energy consumption, the majority of HEIs consume less than 200,000 cubic meters of water. These two plots indicate a scaling issue within the data, necessitating the normalisation of the data for accurate comparisons. By applying appropriate normalisation techniques, the data can be adjusted to ensure a fair and meaningful comparison across HEIs.

Table 4-3 Correlation analysis for energy Vs scope 1 & 2 emissions

Factors	2014-15	2015-16	2016-17	2017-18	2018-19
Total energy consumption (kWh)	0.99	0.99	0.99	0.99	0.99
Total fuel used in HE provider-owned vehicles (litres)	0.15	0.14	0.14	0.17	0.13
Total generation of electricity exported to the grid (kWh)	0.005	0.15	0.07	0.05	0.008
Total water consumption (m3)	0.86	0.88	0.86	0.83	0.85
Total renewable energy generated onsite or offsite (kWh)	0.015	0.12	0.07	0.04	0.07

Table 4-4 Ratio analysis for energy Vs scope 1 & 2 emissions

Scope 1& 2 emission Kg CO_2e	2014-15	2015-16	2016-17	2017-18	2018-19	Improvement
Emissions per energy consumption (kWh)	0.29	0.27	0.25	0.22	0.22	25%
Emissions per fuel used in HE provider-owned vehicles (litres)	394	392	400	338	519	-32%
Emissions per generation of electricity exported to the grid (kWh)	475	568	976	550	352	26%
Emissions per water consumption (m3)	89.81	80.73	77.42	71.44	65.08	28%
Emissions per renewable energy generated onsite or offsite (kWh)	58	50	45	43	45	22%

Table 4-5: Ratio analysis for energy Vs scope 1 & 2 emissions

In order to demonstrate emissions improvement, all the ratios presented in Table 4.4 should exhibit a decrease over the years. Notably, there has been an improvement ranging between 22% and 28% for factors such as emissions per kilowatt-hour (kWh) of energy consumption, emissions per kWh of electricity exported to the grid, and emissions per kWh of renewable energy generated. However, the only factor that did not show improvement in the past five years is emissions per liter of fuel used in owned vehicles. For the majority of ratios in Table 4-4, there is a consistent year-on-year decrease, indicating progress in emissions reduction. Two exceptions are the emissions per fuel (which has shown oscillation) and emissions per generation of electricity exported, both of which peaked in 2016-17. When considering energy consumption as a proxy for the scale of HEI operations, Figure 4-5 reveals no clear relationship between energy consumption and the liters of fuel used in owned vehicles. However, Figure

4-6 demonstrates a linear relationship between energy consumption and water consumption within the HEI. Additionally, there is a lesser correlation between the total area of the HEI and the emissions, as observed in Table 4.1.

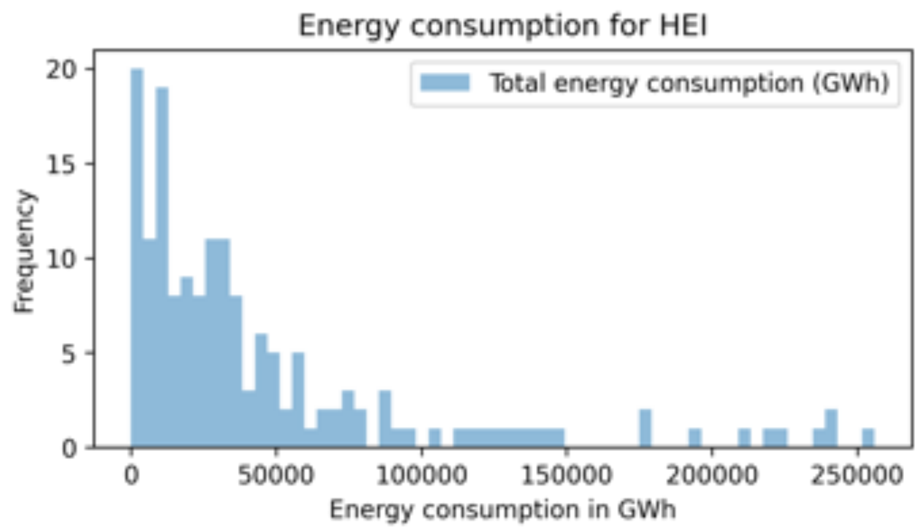


Figure 4-3: The distribution of the energy consumption across the HEIs.

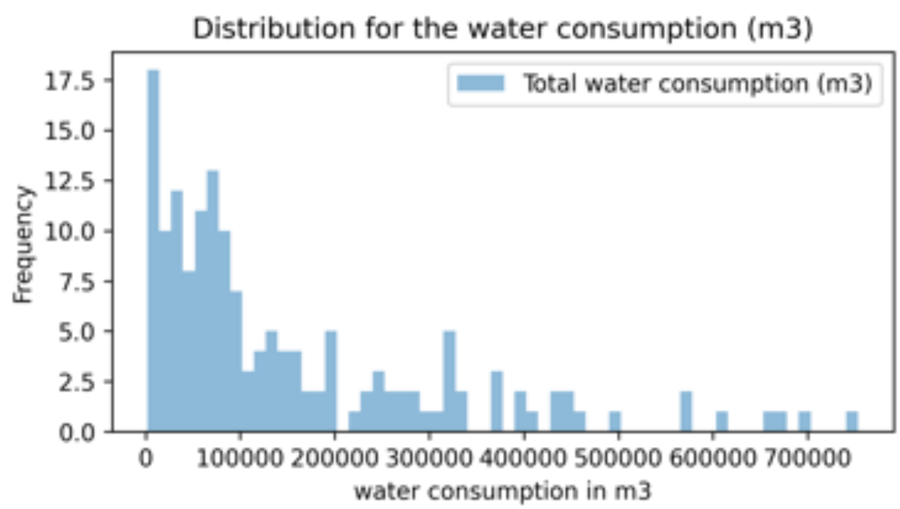


Figure 4-4: Figure 4.2B The distribution of the water consumption across the HEIs.

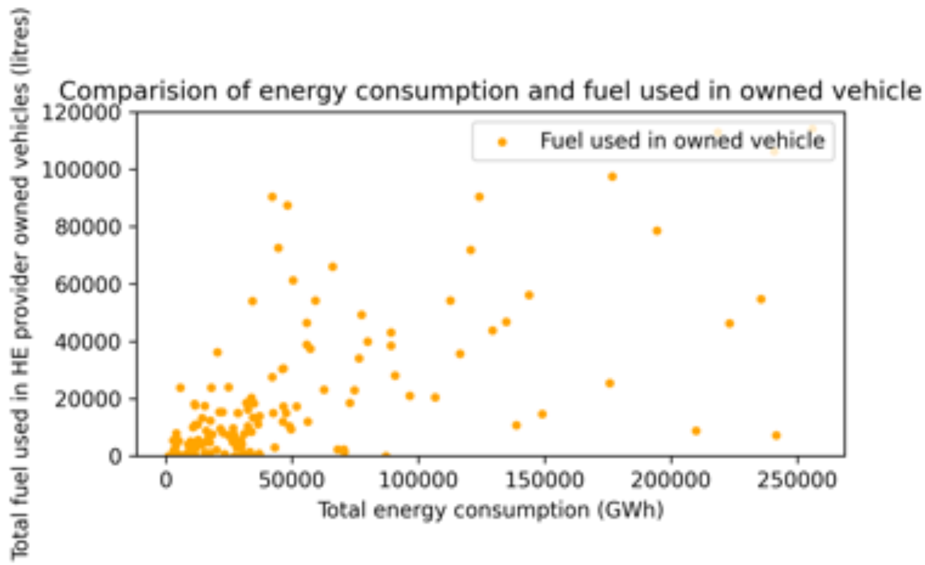


Figure 4-5: The scatter plot showing the relationship between the total energy consumption and the fuel used in the owned vehicle

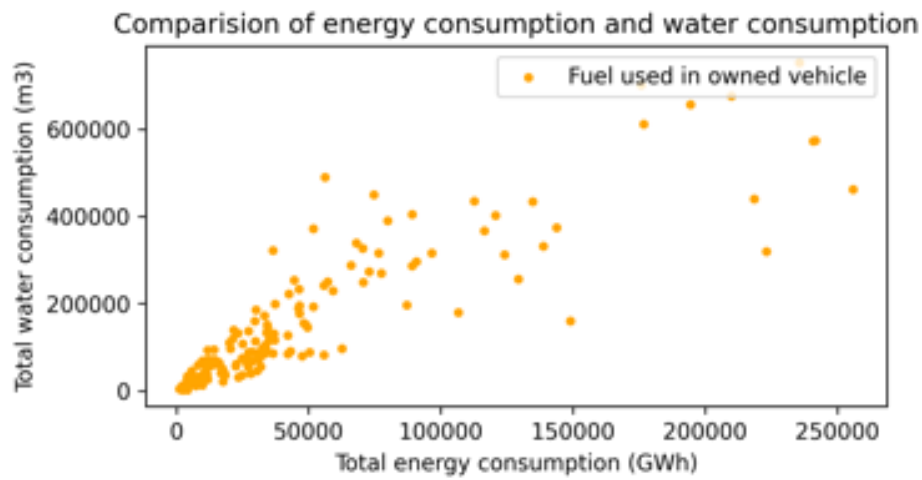


Figure 4-6: The scatter plot showing the relationship between the total energy consumption and the water consumption.

The above analysis shows that the UK HEIs have not decoupled themselves with the energy consumtion, which is essential for reducing emissions. This result also indicates that there has not been a step change in the energy consumption policy at the strategic level.

4.1.3 Finance and people

All the factors within the finance and people section exhibit a strong correlation with scope 1 emissions, as indicated in Table 4-6. Notably, non-residential income, total expenditure, research student FTE, and staff FTE demonstrate the highest correlation, exceeding 0.9. Full-Time Equivalent is defined as “Full-time equivalent (FTE) indicates the proportion of student full-time year being undertaken over the academic year” (HESA, 2022). Among these factors, the emissions per GBP of non-residential income has shown the most significant improvement over the years, with a 47% reduction, followed by teaching income (as shown in Table 4-7). Given that the number of students directly influences the revenue of the HEIs, it is expected that HEIs with a larger student population will also have higher emissions. However, it is worth noting that if collective HEIs have implemented any decoupling measures, these would be reflected in the correlation analysis. Currently, there seems to be no indication that HEIs have made any concerted efforts to decouple business scale from emissions.

Table 4-6 Correlation analysis for energy Vs scope 1 & 2 emissions

Factors	2014-15	2015-16	2016-17	2017-18	2018-19
Teaching income (£)	0.84	0.85	0.86	0.84	0.84
Research income (£)	0.88	0.86	0.87	0.87	0.88
Other non-residential income (£)	0.64	0.57	0.58	0.62	0.63
Non-residential income total (£)	0.92	0.86	0.88	0.9	0.91
Total expenditure (£)	0.92	0.89	0.89	0.91	0.91
Teaching student headcount	0.66	0.67	0.68	0.66	0.65
Research student headcount	0.93	0.93	0.94	0.93	0.93
Teaching student FTE	0.68	0.69	0.70	0.68	0.67
Research student FTE	0.93	0.94	0.94	0.94	0.94
Total staff FTE	0.95	0.94	0.95	0.94	0.95

Table 4-7 Ratio analysis for financing and people Vs scope 1 & 2 emissions

Scope 1& 2 emission Kg CO_2e	**2014-15**	**2015-16**	**2016-17**	**2017-18**	**2018-19**	**Improvement**
Emissions per teaching income (£)	0.12	0.1	0.09	0.08	0.07	40%
Emissions per research income (£)	0.29	0.26	0.25	0.22	0.21	28%
Emissions per other non-residential income (£)	0.5	0.43	0.41	0.31	0.26	47%
Emissions per non-residential income total (£)	0.07	0.06	0.05	0.05	0.06	22%
Emissions per total expenditure (£)	0.07	0.06	0.06	0.05	0.05	34%
Emissions per teaching student headcount	1266	1153	1059	952	852	33%
Emissions per research student headcount	21645	19569	18450	17035	16638	23%
Emissions per teaching student FTE	1417	1281	1168	1043	924	35%
Emissions per research student FTE	25641	23041	21786	21020	19531	24%
Emissions per total staff FTE	6889	6232	5723	5121	4495	35%

4.1.4 Emissions and Waste

Over the study years, total emissions have gradually decreased. Most HEIs emitted less than 25 Gg CO_2e on average in 2014–15, but less than 15 Gg CO_2e on average in 2018–19. The aggregate emissions for 2014-15 was 2,250 Gg CO_2e, and in 2018-19, it reduced to 1363 Gg CO_2e, which is a reduction of 39% in 5 years (see Figure 4-7, Table 4-9). In a similar manner, annual emissions have reduced at both the maximum and minimum levels and shown in the figure 4-8 and 4-9. Figure 4.10 shows the mean and median values for the aggregate emissions for the HEIs. Since there is a significant difference between the mean and median, there is a consistent outlier every year. Figures 4.8 and 4.9 illustrate the maximum and minimum values of emissions, providing a basis for determining the range of values. Any alterations in the consistency of this range over the years can indicate interventions such as changes in the number of HEIs, modifications in methodology, adjustments in data collection practices, or similar factors. Upon examining Figures 4.8 and 4.9, it becomes evident that the trend remains consistent, with no significant deviations observed. This suggests that there have been no substantial disruptions or changes impacting the pattern of emissions over time

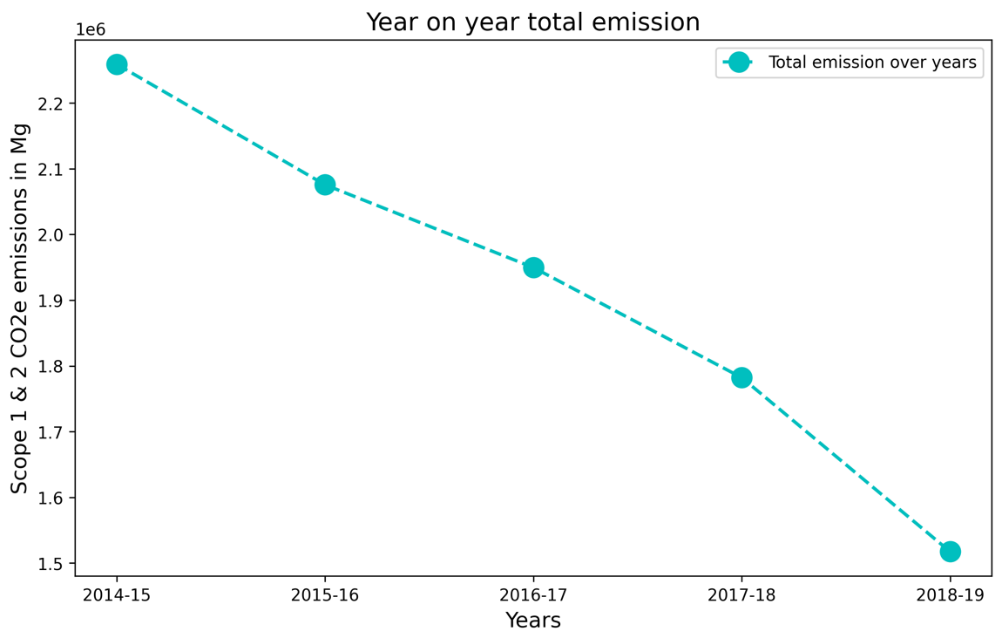


Figure 4-7: Year on year total emissions

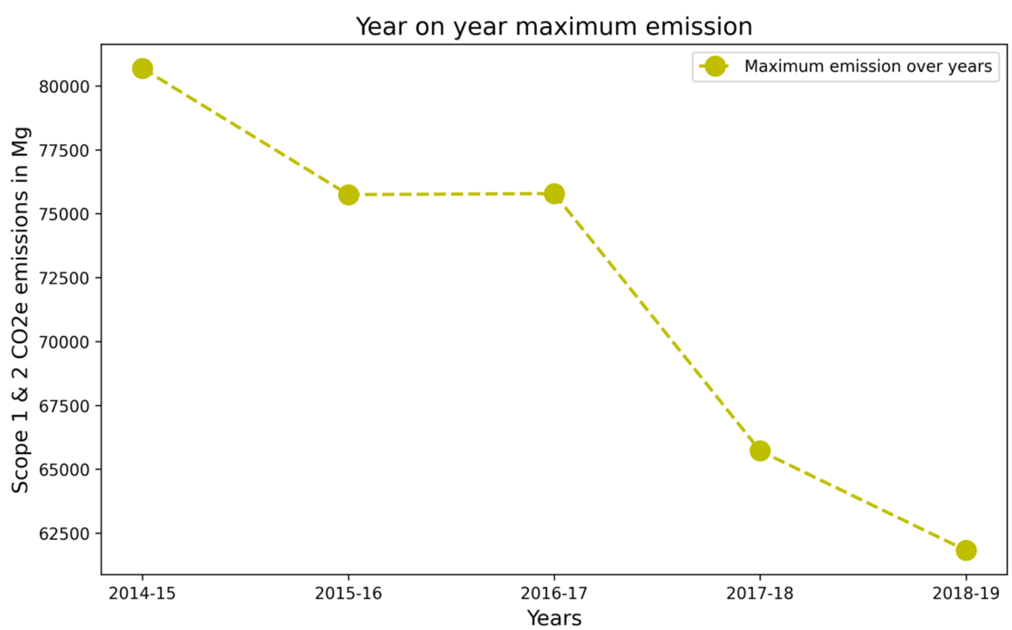


Figure 4-8: Year on year maximum emissions

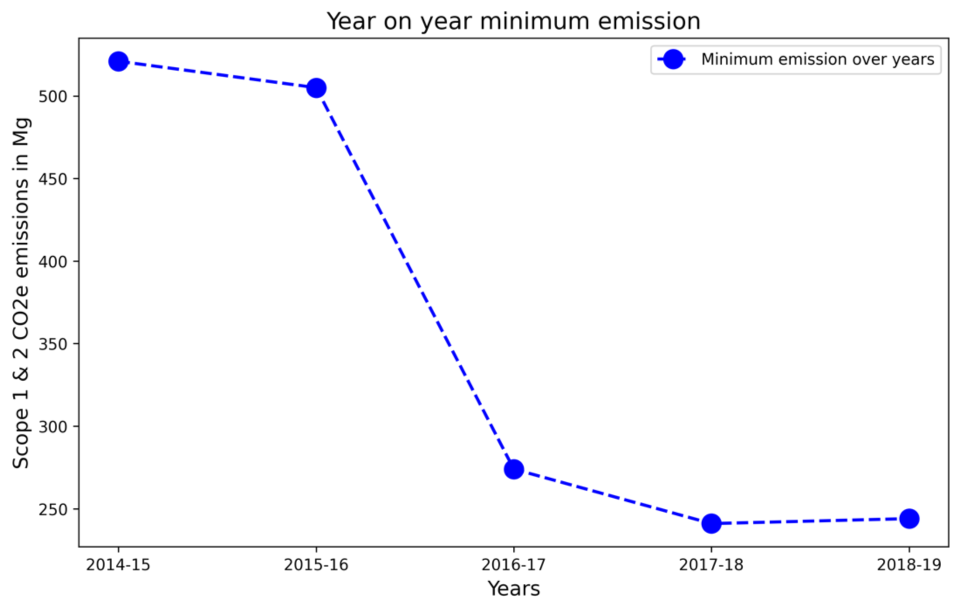


Figure 4-9: Year on year minimum emissions

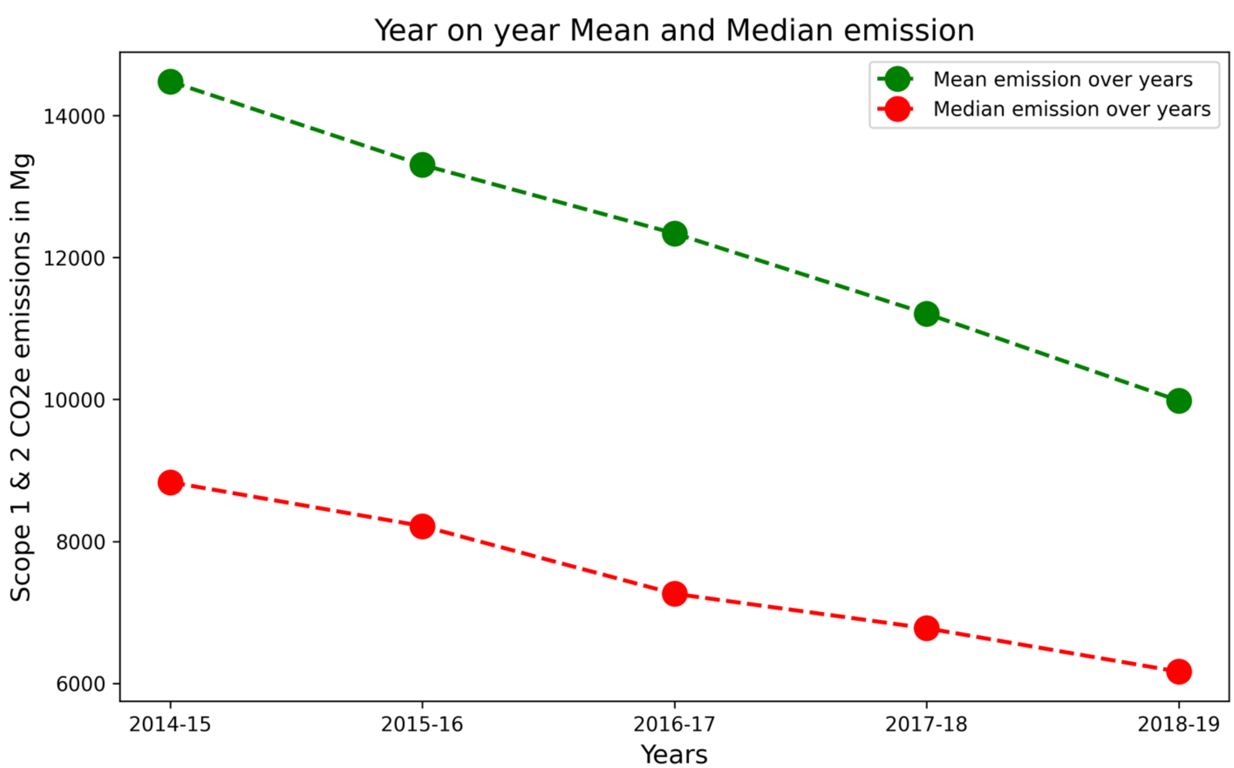


Figure 4-10: Year on year mean and median emission

Table 4-8 The change in emissions at an aggregate level

Year	**Emissions (Gg CO_2e)**	**% Change from baseline**
2005 (baseline year)	2055	NA
2014-15	2250	10% increase
2018-2019	1363	33.7% reduction

4.2 Scope 3 emissions

Over five years, the reporting details related to scope 3 emissions by HEIs have evolved, with greater detail on the activities leading to emissions. Table 4-10 below shows the yearly completeness of the data. "Completeness" is defined as having at least a few breakdowns of scope 3 activity emissions.

Table 4-9 Year on Year completeness of data

Year	Number of HEI record scope 3 activity
2014-2015	4
2015-2016	17
2016-2017	17
2017-2018	17
2018-2019	17
2019-2020	4

The 2018-2019 emission data was chosen for this investigation because it is the most recent and complete set of data that HEI has provided for those emissions.

The first preference was given to SSN data because it has the breakdown of the activities of scope 3 emissions. The breakdown of the activity of scope 3 emissions data dictates the quality of reporting. Other scope 3 reporting quality measures include employing suitable emissions factors, having a consistent reporting structure, and providing a thorough explanation of the emission strategy. The SSN reporting structure omitted a lot of data points, mostly about assessment metrics like the number of student FTE and floor area. HESA open-source data filled up the SSN missing data. The SSN emission reporting structure consists of the following key points:

- Assessment metrices like the number of student FTE and floor area.
- Historic breakdown of the scope 1,2 and 3 emissions
- Break down of the scope 3 emissions (activity data and emission factor)

To compare the respective reporting structures of the HEIs, the three points mentioned above are employed as a characteristic.

Table 4-11 shows the emission data for 17 Scottish HEI. Scope 3 emission data are normalised using total student FTE (taught plus research) and floor area features. Table 4-11 categorises scope 1, 2, and 3 emissions alongside scope 3 emissions per student FTE and scope 3 emissions per floor area.

Since scope 3 reporting is voluntary, the data reported in HESA are limited in content and quality, moreover and there is no baseline year data for scope 3 emissions. These problems do not provide enough data to compare how scope 3 emissions have changed since 2005. Another problem with scope 3 emissions is that there is no standard procedure to calculate them, leading to significant variability in the HEI emission data. In figure 4-12, there is a substantial gap between the mean and median of scope 3 emissions, which indicates several outliers in the data set showing abnormally high or low emissions values. The data derived from the table 4-11 is used throughout the result section and in the discussion section.

There has been a marginal decrease of 10% in aggregate scope 3 emissions from 2015-16 to 2018-19 (Figures 4-11 and 4-12). Scope 3 emissions for the year 2018-19 were 7,780 tonnes of CO_2e, which is 0.5% of scope 1 and 2 emissions. This percentage has remained the same over the last five years (0.4% and 0.5%).

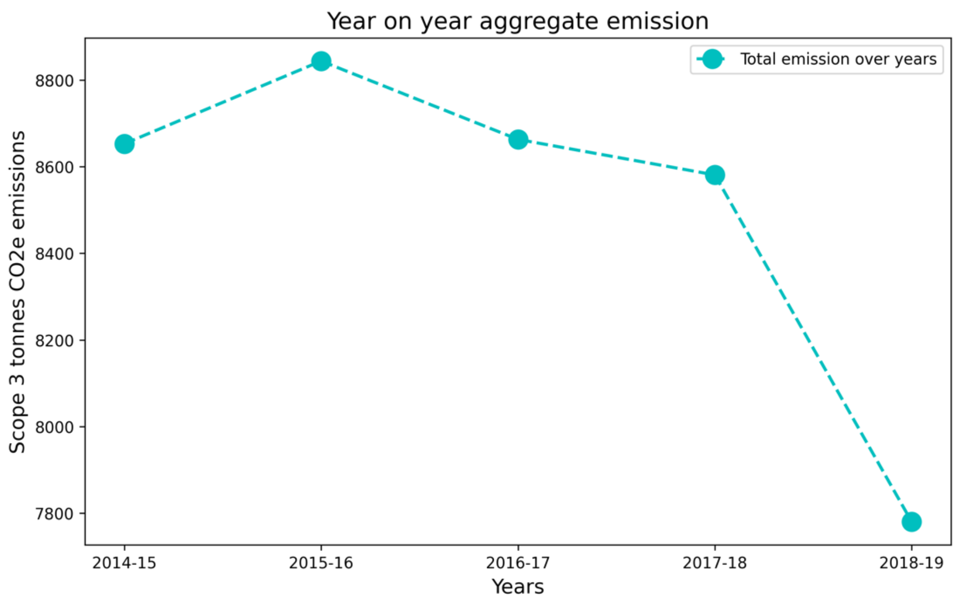


Figure 4-11: Aggregate scope 3 emissions over years

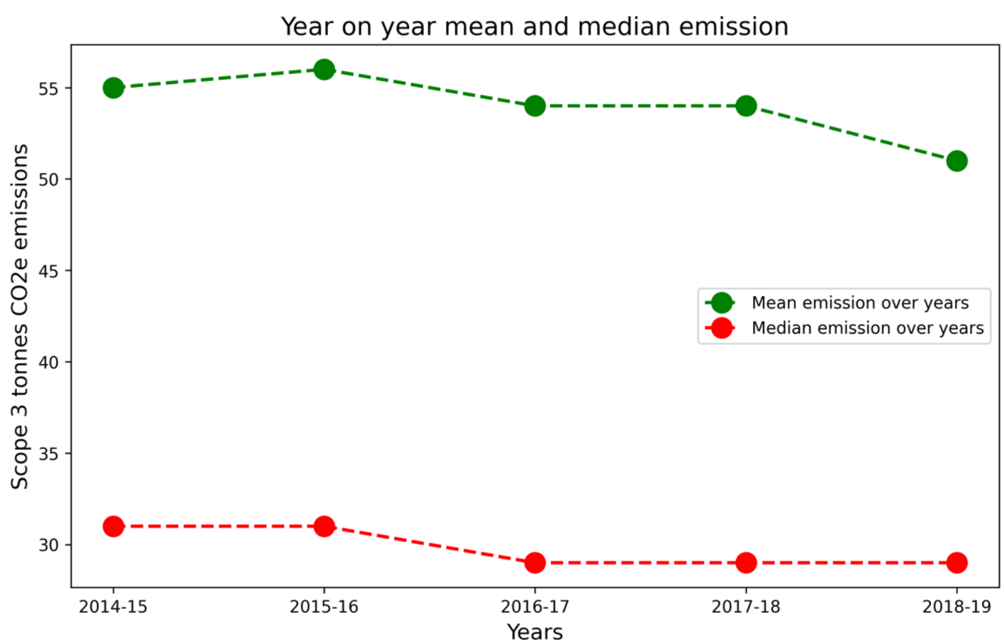


Figure 4-12: Scope 3 mean and median emissions over years

On the HESA website, only three activities—water treatment, water supply, and waste—are available for reporting scope 3 emissions. The remaining scope 3 activities were not recorded. To analyse scope 3 emissions efficiently, a different data source called SSN was used.

Table 4-10 Emissions normalised by FTE and floor area (source: SSN, HESA)

HEI	Total Students FTE	Scope 1 & 2 emissions tCO2e	Scope 3 emissions tCO2e	Scope 3 as % of total emissions	Scope 3 emissions per student	Floor area m2	Scope 3 emissions per floor area
SRUC (2018-19)	1505 (1370)	4862.77	991.75	16.9%	0.65	184441	0.0053
Glasgow school of art (2017-18)	2205 (2125)	NA	1379.8	NA	0.62	NA	NA
Aberty University (2018-19)	3664 (3910)	2091	530	20.2%	0.14	38896	0.014
Queen Margaret University	3665 (3890)	1354	1743	56.3%	0.48	46784	0.037
University of the Highlands and Islands	NA (7135)	393	125	24.1%	NA (0.02)	6883	0.018
Robert Gordon University	NA (8195)	5632	319.6	5.4%	NA (0.04)	73410	0.004
The University of St Andrews	9375 (9145)	14959	7098	32.2%	0.75 (0.77)	264605	0.027
Heriot-Watt University	NA (9165)	12931	4543	26%	N.A. (0.49)	N.A.	N.A.

The University of Stirling	9653 (9350)	10038	271	2.6%	0.03	164811	0.02
Edinburgh Napier University	NA (10815)	3798	2625	41%	N.A. (0.24)	N.A.	NA
Glasgow Caledonian University	14282 (11175)	6550	13887	68%	0.97	87302	0.16
The University of Dundee	NA (11820)	19654	5945	23%	N.A. (0.5)	N.A.	N.A.
The University of Aberdeen	12409 (12620)	17140	4192	19.7%	0.33	198841	0.008
The University of the West of Scotland	NA (14270)	5299	1107	17.3%	NA (0.08)	NA	NA
The University of Strathclyde	NA (18475)	22593	688	0.03	NA (0.04)	347876	NA
The University of Glasgow	NA (26615)	34886	25502	42.2%	NA (0.95)	445473	0.06
The University of Edinburgh	43380 (30895)	60285	31106	34%	0.72	930000	0.03

4.3 Conclusion: Explolatory data analysis- Scope 1,2 & 3

Section 4.1 presents data insights on scope 1 and 2 emissions over a five-year period. The study focused on identifying trends, patterns, and correlations among the emissions components of the HEI, utilising the available data. In order to assess the impact of various components on scope 1, 2, and 3 emissions, the study employed several approaches, including correlation analysis, factor analysis, and ratio analysis. Notably, emissions consistently exhibited a strong correlation with the following factors:

- Total gross internal area
- Total staff FTE
- Research student FTE
- Non-residential income total (£)
- Total expenditure (£)
- Water consumption
- Energy consumption

Similarly, the maximum improvement in the normalised emission was observed in:

- Other non-residential income (£)
- Total number of cycle spaces
- Total grounds area (hectares)
- Teaching income (£)
- Total site area (hectares)
- Teaching student FTE
- Total staff FTE

The correlation between energy consumption and CO2 emissions has been widely established (Ward et al., 2008; Pérez-Lombard, 2008). The most effective approach to reducing emissions is by decoupling energy consumption from emissions. The findings of this study reveal a consistent correlation of 0.99 between energy consumption and emissions over the past decade. However, it is not objectively evident from the data whether HEIs have successfully decoupled energy consumption and emissions. While there has been an approximate 25% improvement in emissions per unit of energy consumption in the last five years, it is insufficient to achieve a significant decoupling of emissions. If decoupling proves to be a complex challenge, the primary focus should be on replacing fossil fuel-based energy with renewable energy sources. Although the correlation would still remain high in this scenario, the absolute emissions would decrease. Additionally, it is important to ensure that the life cycle emissions of the renewable energy generation systems are also low (Amponsah et al., 2014).

The parameters related to the area, as presented in Tables 4-1 and 4-2 earlier, play a significant role in driving scope 1 and scope 2 emissions. The age of buildings in UK's HEIs varies considerably. For example, RGU is a relatively modern university compared to the centuries-old Oxford and Aberdeen Universities. Addressing the high energy consumption of outdated buildings in HEIs can be approached in two ways: renovating the buildings to improve energy efficiency or replacing them with new construction. Theoretically, taking a life cycle approach, constructing a new building is more advantageous in terms of emissions reduction compared to retrofitting (Onat et al., 2015). However, demolishing a historic structure may not be feasible for constructing a low-emissions building (Feilden, 2007). In such cases, retrofitting the historic building becomes the more practical solution. When a retrofit is performed, it directly impacts scope 1 and 2 emissions by reducing energy consumption. However, it also increases scope 3 emissions by adding the upstream emissions of the retrofit materials (Giesekam, 2014). Therefore, HEIs must also ensure that the upstream emissions associated with retrofit materials are minimised.

Although it appears that all HEIs have made efforts to reduce emissions, they have not yet reached the set target. In comparison to the projections made in the Bright report, which suggested a possible 23% decrease, the current situation shows that HEIs have achieved an overall emissions reduction of 35%. By 2020, only 48 HEIs had achieved a 43% reduction (Figure 4-13 below). However, due to the pandemic, the year 2020 is not considered operational for HEIs, and therefore, data up until the 2018-19 academic year is regarded as the target year. The data indicates that HEIs were slow to respond to climate change initiatives when awareness and regulations first began in 2006-2008. There was no significant reduction in aggregate emissions until 2014-2015. From 2015 to 2019, UK HEIs managed to reduce their aggregate emissions by 34%. However, they fell short of meeting the 2020 milestone. The 2020 milestone could have been achieved if the emissions reduction initiative had been initiated earlier in the decade. The concept of emission reduction in HEIs was relatively new in 2006-2008 when the climate change initiative commenced. The slow adaptation of climate change policies among HEIs may be attributed to the learning curve they had to navigate in the initial stages.

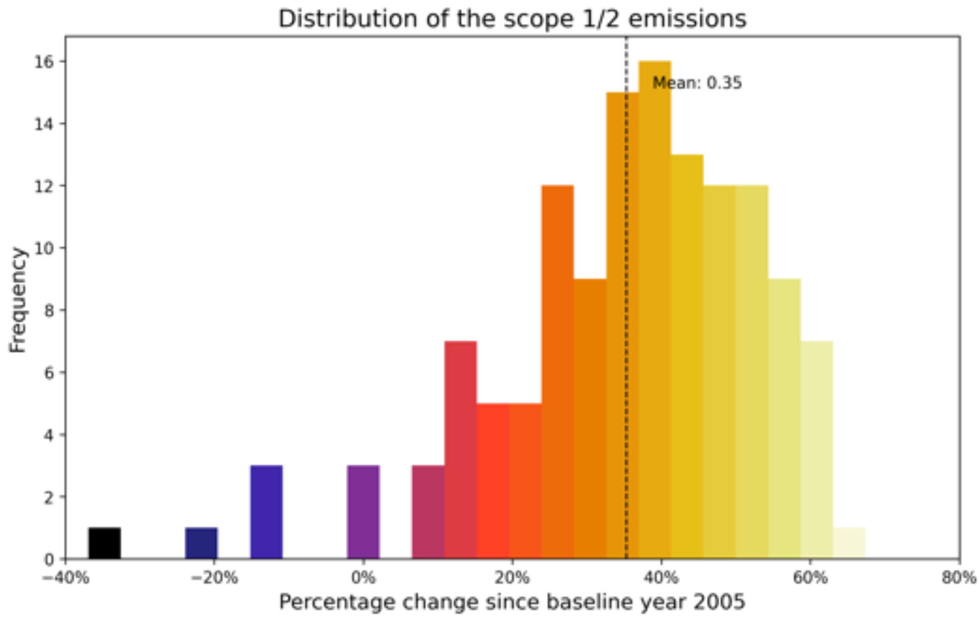


Figure 4-13: The X-axis shows the percentage change in emission where positive value is reduction and negative value is increase in emissions.

The y-axis is the frequency count for bins. The plot indicates that most of the HEIs fall on the left hand side of the mean and the benchmark value of 43%, which means that that fail to meet the emissions

HESA data was utilised to analyze the scope 1 and 2 emissions of HEIs. While the HESA data provides comprehensive coverage of scope 1 and 2 emissions, it has limitations in capturing scope 3 emissions from certain sources, namely:

- Total scope 3 carbon emissions from waste (tonnes CO2e)
- Total scope 3 carbon emissions from water supply (tonnes CO2e)
- Total scope 3 carbon emissions from wastewater treatment (tonnes CO2e)

The scope 3 data indicates that these emissions account for only 0.5% of the total emissions, which is evidently inaccurate. To address this issue, SSN data was employed to capture scope 3 emissions. The SSN data encompasses all the emission sources recorded by HEIs and provides a clearer understanding of their efforts and actions concerning scope 3 emissions. The SSN data analysis is shown in next section.

5. Scope 3 emissions reporting by Scottish HEIs

5.1 Scope 3 emission as a percentage of total emissions

To analyze the proportion of scope 3 emissions in relation to total emissions, the seventeen HEIs were divided into five clusters. These clusters were created based on the percentage of scope 3 emissions compared to the total emission. It is worth noting that the Glasgow School of Art was excluded from the fifth cluster due to incomplete emission data.

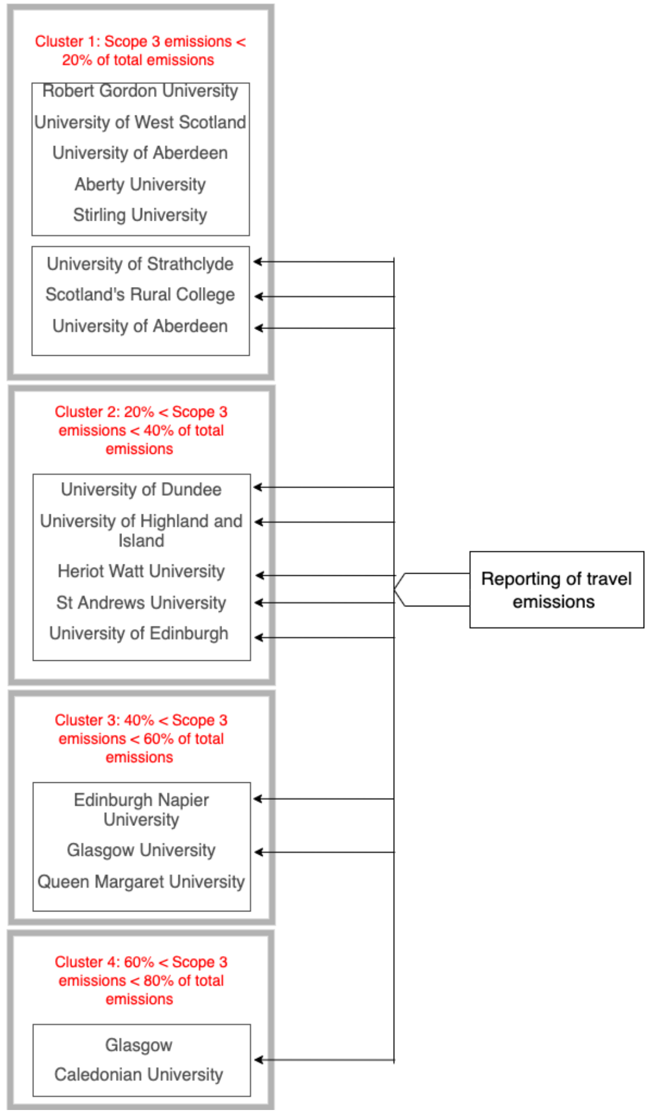


Figure 5-1: : HEIs arranged in the ascending order of scope 3 emissions percentage of total emissions. The arrow indicates the HEI reporting the travel-related emissions.

Seven HEI comprise the first cluster, accounting for less than 20% of the total emissions from scope 3. Among these seven HEIs, four did not report any travel-related emissions. The three HEIs that reported flight emissions are the University of Strathclyde, SRUC and the University of Aberdeen. The University of Aberdeen is the sole institute that provides a breakdown of all emissions associated with travel. The remaining four HEIs primarily contribute to the scope 3 emissions through water treatment and supply. In the second cluster, five HEIs have scope 3 emissions ranging from 20% to 40% of the total emissions. Within this cluster, the University of Dundee, the University of Edinburgh, and St Andrews University have provided more detailed scope 3 activity data. They include a breakdown of flights into long-haul, short-haul, and domestic categories as well as emissions from other transportation modes such as buses, cars, and taxis. Year to year statistics can be utilised to identify any shift in the usage of trains and other forms of the public transportation as alternative to air-travel.

The Queen Margaret University (QMU) stands as an outlier within the third cluster due to its lack of reporting on travel-related emissions. Nonetheless, it is grouped alongside Edinburgh Napier University (ENU) and the University of Glasgow. The latter two institutes provide a detailed breakdown of the scope 3 emissions. Furthermore, while QMU is more focused on arts, drama, and social science, ENU and University of Glasgow demonstrate active engagement across disciplines such as management, arts, science, and engineering. Moving to the fourth cluster, Glasgow Caledonian University is the sole HEI present, and it excels in providing in-dept data regarding emissions.
There are three main components of travel-related emissions which are:

1. Staff/student commute to work
2. Staff/student business travel, which may include travel for meetings, conferences, and teaching
3. International student travel: The existing literature has demonstrated a divergence of opinions regarding the responsibility of Higher Education Institutions (HEIs) for international student air travel. Davies and Dunk (2016) assert that universities create opportunities for international students, thereby holding universities accountable for the associated emissions. Conversely, Bazylak et al. (2020) argue that universities are only responsible for the travel they financially support. Consequently, emissions resulting from international student and staff travel that is not funded by the university are not considered in the emissions calculations. By attributing emissions based on the party responsible for financing the travel, the issue of double counting can be mitigated, as a single HEI would be accountable for each trip. However, it is worth noting that the calculation of Scope 3 emissions is still in its nascent stage and encompasses considerable uncertainties. Therefore, HEIs are encouraged to adopt a top-down approach, wherein they record all travel emissions and assume responsibility for them, regardless of the funding source. As the reporting framework evolves, HEIs can subsequently refine their approach by implementing more precise emission assignments. Additionally, it is important to recognize that double counting is not a significant concern at the micro level.The following factors broadly determine the factors driving the staff-student commute to work:
   - The number of students living in the HEI accommodation and its location from the campus:

If a more significant proportion of students live in HEI accommodation closer to the campus, then there will be fewer commuting-related emissions. The relationship is explained in the form of a 2X2 matrix in table 5-1

Table 5-1 2X2 matrix to explain the factors driving the commute emissions

	A big proportion of students living in HEI accommodation	A small proportion of students living in HEI accommodation
HEI accommodation is far away from the campus	Higher emissions	Uncertain
HEI accommodation is closer to the campus	Less emissions	Uncertain

The number of students living in HEI housing, away from campus, increases the amount of emissions caused by commuting. On the other hand, the emissions will be lower if the lodging is closer to the school. Nevertheless, the situation becomes uncertain if:

HEI accommodation is far from the campus, and a small proportion of students live there. The uncertainty factors are the distance of HEI accommodation and the ratio of students living there. The impact will be less if the percentage of students living in HEI accommodations are far away. On the other hand, if the HEI accommodation is far away, a sizable number of people live there and commute to campus by car, then emissions will be significant.

- The location of the HEI campus with respect to the city centre also influences commute emissions. If the HEI campus is within the city centre, walking, cycling, and public transport commuting is easier. More vehicle-related emissions are expected if the campus is outside the city limits (or far away from the city centre).
- The residency of the staff (distance from the campus)

The following section shows how each HEI has reported its travel commute emissions. It also compares scope 1& 2 emissions. This section shows the result based on the clusters described in figure 5-1.

5.1.1 Scope 3 emissions analysis for cluster 1

Cluster 1 comprises HEIs that have reported scope 3 emissions amounting to less than 20% of their total emissions. The HEIs falling within this cluster include RGU, University of Aberdeen (UoA), University of Stirling, Abartey University, University of West of Scotland, University of Startchlyde (UoSt), and SRUC. Among these, UoSt, SRUC, and UoA have reported travel emissions, while the remaining HEIs in this cluster have not reported either travel emissions or commute emissions. This finding contradicts the existing body of research, which suggests that scope 3 emissions should account for up to 75% of the total emissions (Huang et al., 2009). The detailed analysis reveals that the literature may be valid, as out of the six HEIs, only three have reported travel emissions, and none of the HEIs have reported commute emissions. Furthermore, the HEIs' incomplete reports of travel emissions only include a limited range of activities. Consequently, the omission of commute emissions results in a smaller proportion of scope 3 emissions compared to scope 1 and scope 2 emissions. By not reporting commute emissions, the absolute value of scope 3 emissions is automatically reduced, making it a smaller percentage when compared to scope 1 and scope 2 emissions.

University of Aberdeen

Table 5-2 Budget normalised emissions for the University of Aberdeen

Year	Budget (GBP)	Scope 3 tCO2e	Scope 3 emissions tCO2e/GBP (million)	Total emissions tCO2e	Total emissions tCO2e/GBP (million)
2015	236,674,000	5,486	23.24	28,160	119.3
2016	236,674,000	5,958	25.24	31,520	133.6
2017	229,962,000	4,755	20.8	27,989	122.2
2018	222,462,000	4,337	19.5	24,455	110.2
2019	219,471,000	4,192	19	21,332	97.4
2020	228,494,000	2,994	13.13	20,738	91
2021	233,771,000	1,331	5.6	16,992	72.7

Table 5-2 demonstrates that, with only small variations, the UoA budget has stayed constant for six years. The scope 3 emissions and the total emissions have been reduced, which has improved the normalised value of the scope 3 emissions with respect to a million GBP spent. The reduction in scope 3 emissions is 50%, whereas total emissions were reduced by 40% across the six years.

UoA reported travel-related emissions within scope 3, shown in figure 5-2 below.

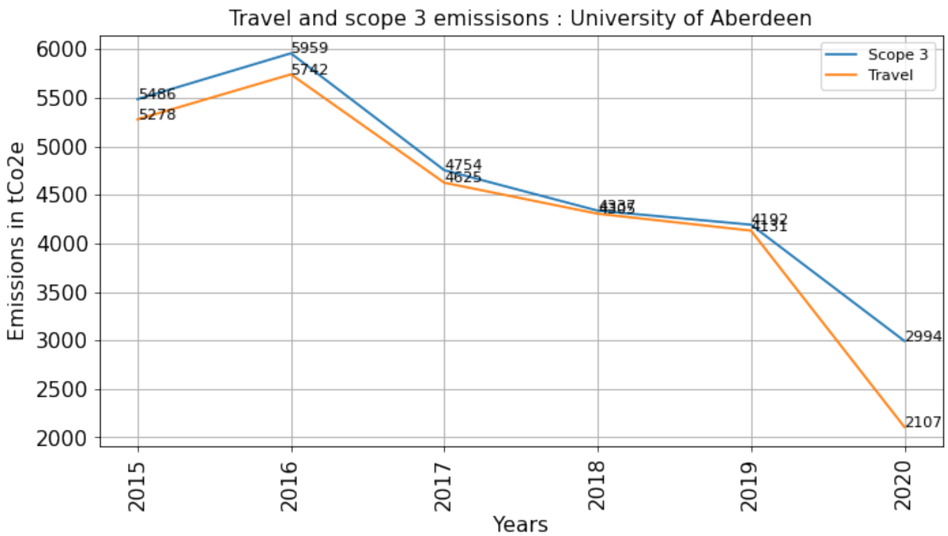


Figure 5-2: Comparison of travel and scope 3 emissions: University of Aberdeen

Figure 5-2 illustrates that travel emissions constituted more than 90% of the scope 3 emissions during the initial five-year period. This observation raises the possibility of selective reporting, wherein only significant scope 3 components were included, or an overabundance of travel emissions. Apart from travel, scope 3 emissions also encompass recycling and landfill emissions. However, it should be noted that recycling and landfill make up a small proportion of the overall scope 3 emissions. It is worth noting that the report did not account for water supply and transport, as well as grid transmissions, as part of the scope 3 emissions. These emissions should fall under scope 3 since they occur beyond the HEI's premises and are beyond its direct control. For instance, in 2017 and 2018, emissions from water supply and treatment, as well as grid transmissions, accounted for 16.4% and 14.8% respectively. However, in the 2020 report, this oversight was rectified, and water supply, transportation, and grid transmissions were appropriately categorised under scope 3. Figure 5-2 demonstrates that travel emissions constituted over 90% of the scope 3 emissions from 2015 to 2019, while in 2020, they accounted for 70%. It is important to note that no publicly available information is provided on commute emissions, despite the

University of Aberdeen reporting travel emissions in the SSN. Additional relevant documents available on their website include the University of Aberdeen Sustainable Travel Plan 2018-2022, which outlines guidelines for reducing travel emissions for staff and students, along with specific targets (Osbeck, C (2017)). However, there is a lack of follow-up data to assess the HEI's progress towards meeting its targets, and the CMP 2016 to 2021 does not incorporate staff and student commuting to campus (University of Aberdeen, 2017). Figure 5-3 depicts the relationship between total emissions and scope 3 emissions for the University of Aberdeen. Notably, natural gas emissions account for more than 50% of scope 1 emissions, contributing to the widening gap between scope 1 and scope 3 emissions.

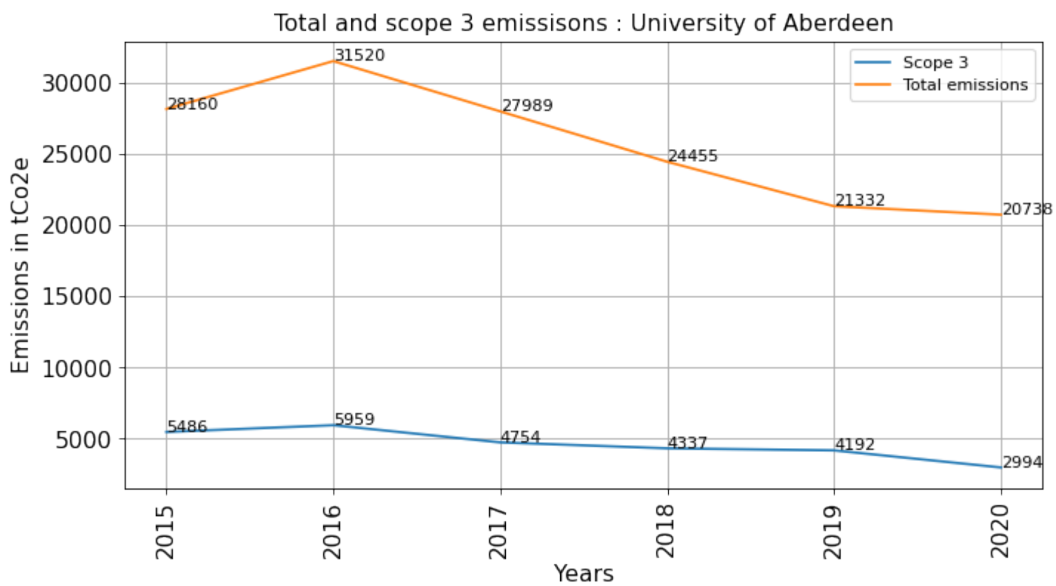


Figure 5-3: Comparison of scope 3 and total emissions for the University of Aberdeen

University of Strathclyde

The 2015 report from the University of Strathclyde (UoSt) is incomplete, as it only addresses transportation emissions and water supply, neglecting to include scope 3 emissions in other areas. The corresponding fields or activities related to scope 3 emissions were left blank or unaccounted for. Table 5-3 presents the allocated budget and the emissions normalised by budget.

Table 5-3 Budget normalised emissions for the University of Strathclyde

Year	Budget (GBP)	Scope 3	Scope 3 emissions/GBP (million)	Total emissions	Total emissions/GBP (million)
2015	254,337,000	1,749	6.88	31,570	124.3
2016	280,867,000	1,753	6.2	30,071	107.4
2017	295,865,000	1,562	5.3	27,035	91.6
2018	304,414,000	1,179	3.9	23,205	76.3
2019	336,216,000	668	2	23,281	69.3
2020	331,132,000	6,690*	20.2	NA*	NA*
2021	290,387,000	1,452*	123	NA*	NA*

(*see section 5.1 for the anomaly in scope 3 emissions reporting)

From 2015 to 2019, there was a 32% increase in the budget, while scope 3 emissions decreased by over 70% and total emissions decreased by 40%. Table 5-3 illustrates a significant reduction in scope 3 emissions per million GBP compared to total emissions per GBP. The calculation of scope 3 emissions has gradually improved from 2015 to 2019, resulting in high data variance. On the other hand, scope 1 and scope 2 emissions are reasonably accurate, leading to low variance in total emissions per million GBP. The pie chart, Figure 5-4, demonstrates the progress in scope 3 emission reporting. In 2016, grid transmission accounted for the majority of scope 3 emissions at 81%, but by 2019, it comprised only 4% of the emissions. Meanwhile, travel emissions increased from 8% in 2016 to 75% in 2019. In 2019, the UoSt began including commute emissions, which contributed 19% to the scope 3 emissions. Therefore, travel and commute emissions combined accounted for 94% of the scope 3 emissions in 2019.

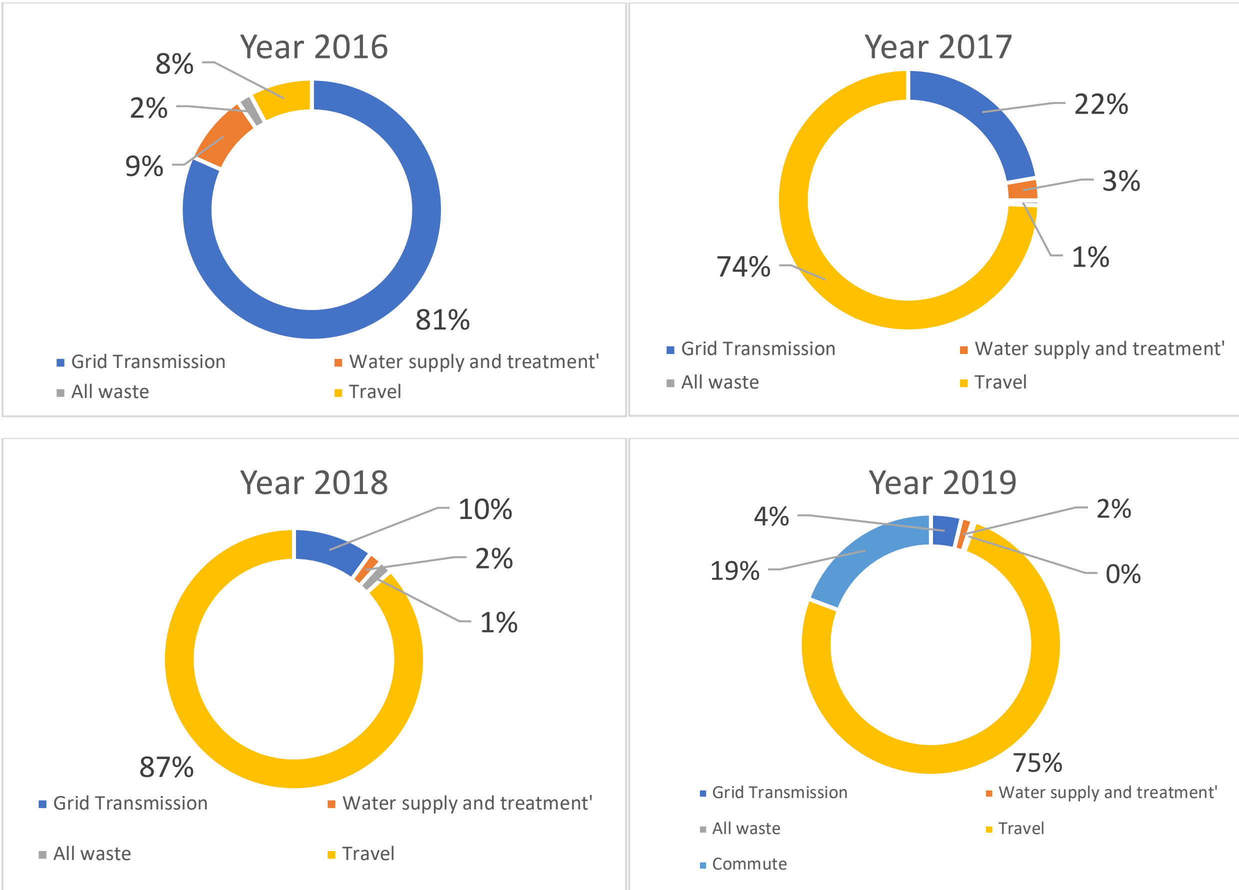


Figure 5-4: Year-wise scope 3 emission split for the University of Strathclyde

UoSt reported travel emissions as well as partial commute emissions in 2019. More detailed information regarding commute and travel emissions can be found in their travel plan document for 2021 (University of Strathclyde, 2021). The travel plan document also outlines several Key Performance Indicators (KPIs) related to travel emissions, with a specific focus on reducing single occupancy vehicle use among students and staff. It is noted that both of these targets were achieved in 2020. However, the document does not provide an explanation of how these targets will directly impact scope 3 emissions. Additionally, the document mentions a target for increasing cycling space, but this target was not met until 2020. However, the results presented in the document do not elaborate on how these specific targets will influence scope 3 emissions.

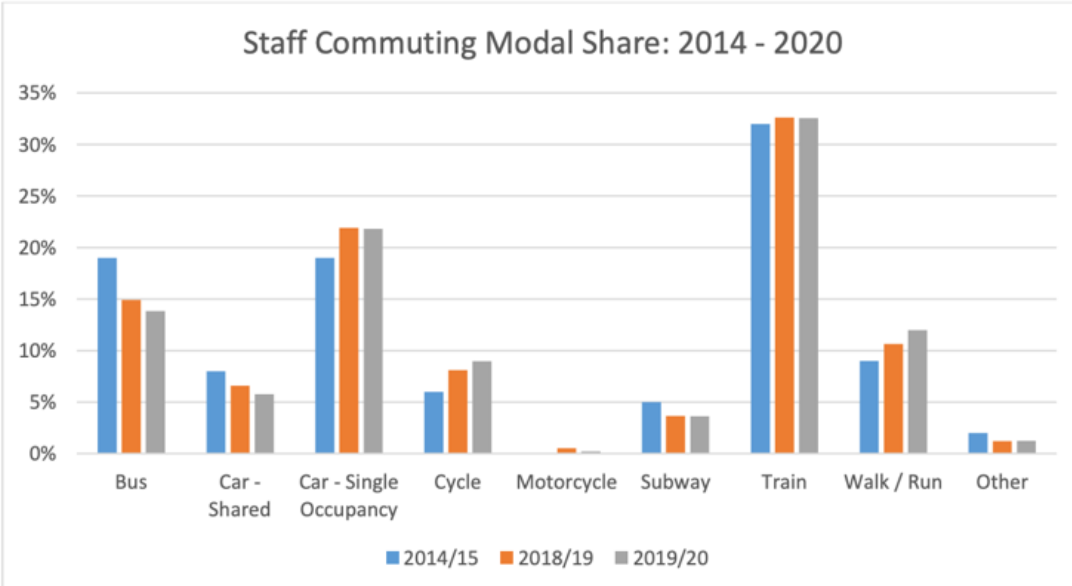


Figure 5-5: Staff transport modal split

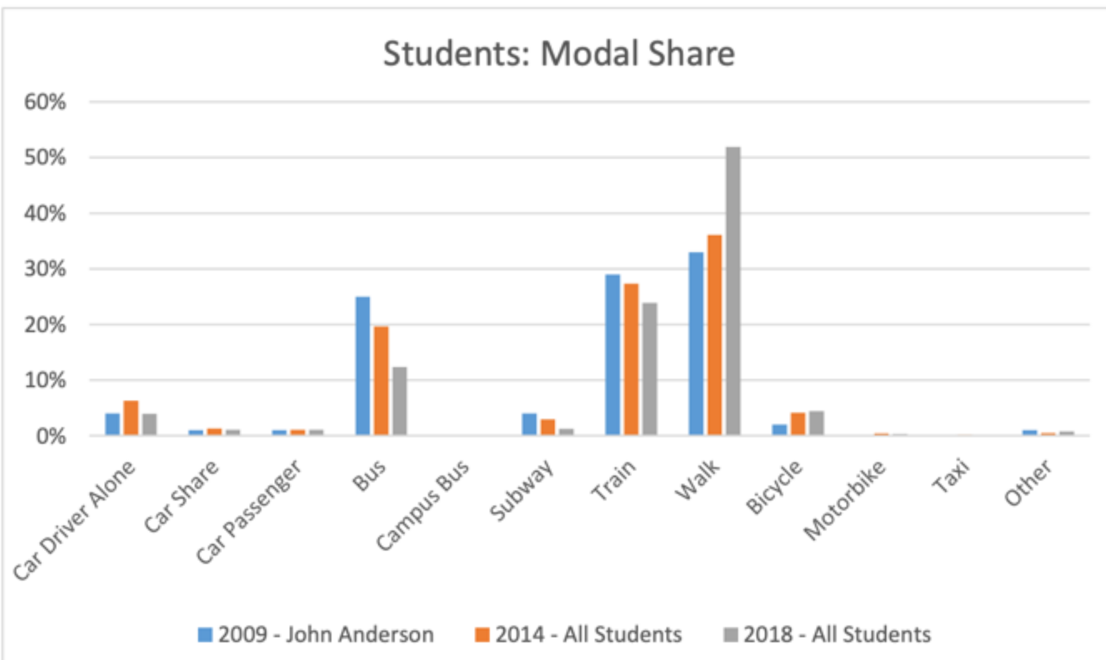


Figure 5-6: Student transport modal split

(Source: University of Strathclyde Travel plan 2021)

Figure 5-5 and 5-6 illustrate the percentage distribution of the transport modes used for commuting. The analysis reveals that a significant proportion of employees choose to commute by train (30%), followed by single occupancy cars (20%) and buses (15%). Conversely, the majority of students opt for walking

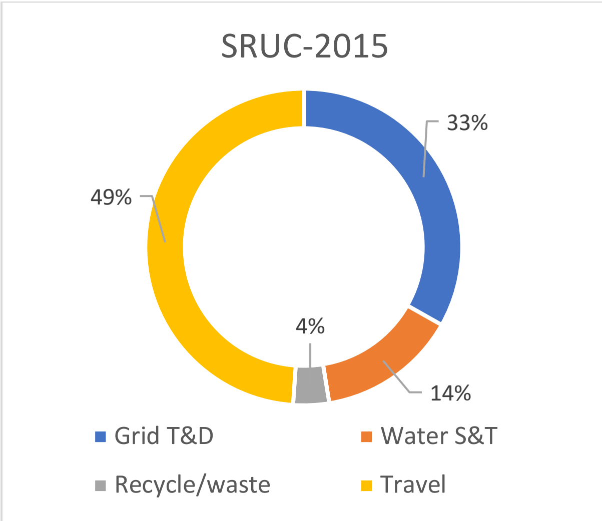
(35%) and utilise rail transport (30%), single occupancy cars (20%), and buses (20%) for their commute. Based on these findings, it can be inferred that the commuting patterns of staff members are more carbon-intensive compared to those of students. It is worth noting that since the data is presented in percentages, there is no explicit estimation of scope 3 commute emissions. Furthermore, the University of Strathclyde has not yet reported any data on commute emissions.

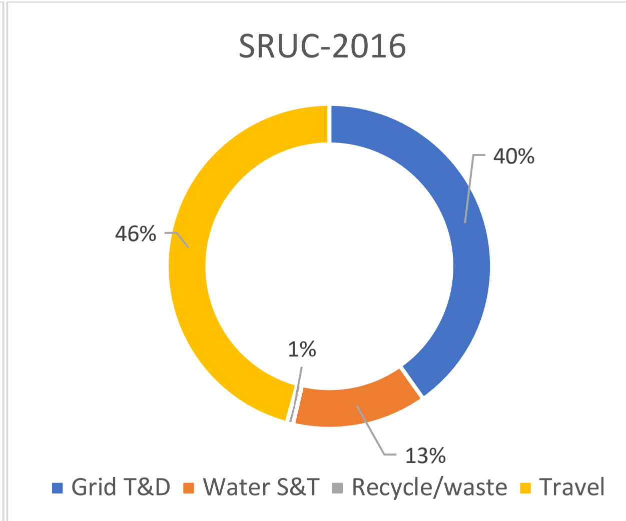
Scotland's Rural College (SRUC)

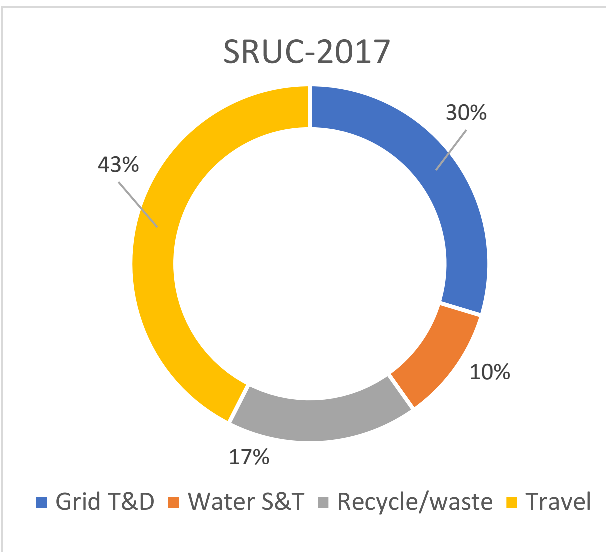
Table 5-4 Budget normalised emissions for SRUC

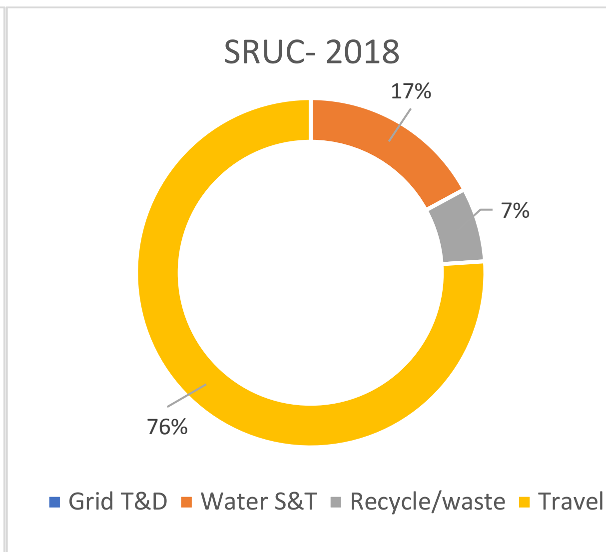
Year	Budget (GBP)	Scope 3 tCO2e	Scope 3 emissions/GBP (million)	Total emissions tCO2e	Total emissions/GBP (million)
2015	73,400,000	803	10.9	9,668	131.7
2016	74,400,000	881	11.8	8,600	115.5
2017	77,114,000	1074	13.9	7,331	95
2018	78,214,000	586	7.4	6,931	88.6
2019	75,384,000	992	13.7	5,854	77.7
2020	85,000,000	579	6.8	5,327	62.6
2021	80,625,000	202	2.5	3,079	38.2

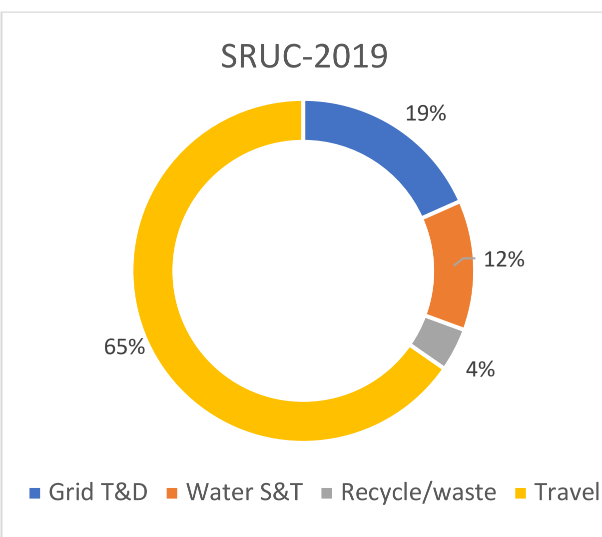
Table 5-4 demonstrates a consistent reduction in scope 3 emissions in relation to each million GBP spent. However, it is important to note that there is a significant variance in these emissions. The overall emissions per GBP exhibit a consistent and uniform downward trend. It is worth mentioning that in 2017, there was a noticeable increase in GBP-normalised emissions due to the inclusion of excessive reporting of recycling emissions. In the year 2015, scope 2 emissions erroneously encompassed grid transmissions and distribution emissions, which were misclassified. If these emissions had been correctly categorised, it would have resulted in a 49% increase in scope 3 emissions. Additionally, scope 2 emissions for that year encompassed travel, recycling and water supply, as well as transport emissions. However, in 2016 and 2017, scope 3 emissions were reported accurately. Grid transmissions and distribution were not reported in 2018 but were reported again in 2019.


SRUC-2015
33%
49%
4%
14%
Grid T&D
Water S&T
Recycle/waste
Travel


SRUC-2016
40%
46%
1%
13%
Grid T&D
Water S&T
Recycle/waste
Travel


SRUC-2017
30%
43%
10%
17%
Grid T&D
Water S&T
Recycle/waste
Travel


SRUC- 2018
17%
7%
76%
Grid T&D
Water S&T
Recycle/waste
Travel


SRUC-2019
19%
12%
65%
4%
Grid T&D
Water S&T
Recycle/waste
Travel

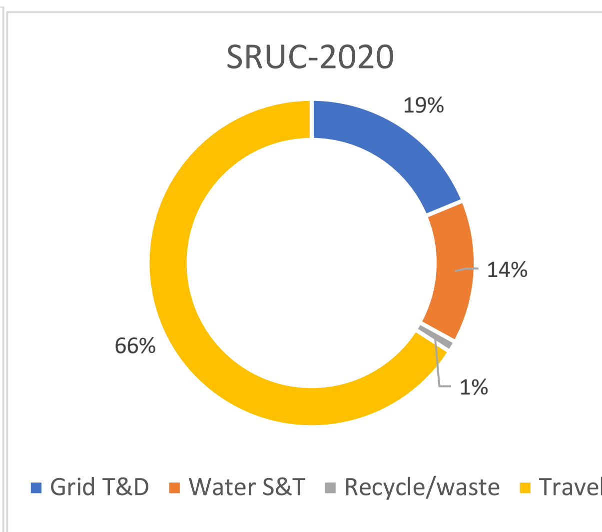

SRUC-2020
19%
14%
66%
1%
Grid T&D
Water S&T
Recycle/waste
Travel

Figure 5-7: Year-wise scope 3 emissions split for SRUC

Figure 5-7 presents the distribution of scope 3 emissions across various categories, including grid transmission, water supply and treatment, trash recycling, and travel. It is important to note that SRUC has calculated travel emissions but has not included commute emissions in their reporting. Inconsistencies can be observed in the reporting of grid transportation, water treatment and supply, and recycling in Figure 5-7. Some erroneous reporting instances include the fluctuating water supply and treatment emissions over the span of five years, ranging from one percent to twenty-five percent. Additionally, grid transmission and distribution emissions were not reported in 2018. On the other hand, travel emissions consistently contribute a significant proportion to scope 3 emissions, ranging from 50% to 75%. There is a considerable potential for improvement in scope 3 reporting by focusing on addressing easily identifiable issues, such as reporting grid emissions accurately. Notably, since 2017, there has been a discrepancy in the reporting of trip emissions, with lease and pool cars equipped with typical diesel engines of unknown sizes being reported as scope 1 emissions instead of scope 3 emissions. Car emissions make a substantial contribution to scope 3 emissions. When these emissions are correctly classified and included in scope 3, they should be plotted separately rather than combined with scope 3 emissions. This rectification is crucial to ensure accurate representation and avoid misinterpretation of travel emissions as higher than scope 3 emissions. Addressing such straightforward errors can significantly enhance the accuracy of scope 3 emissions reporting.

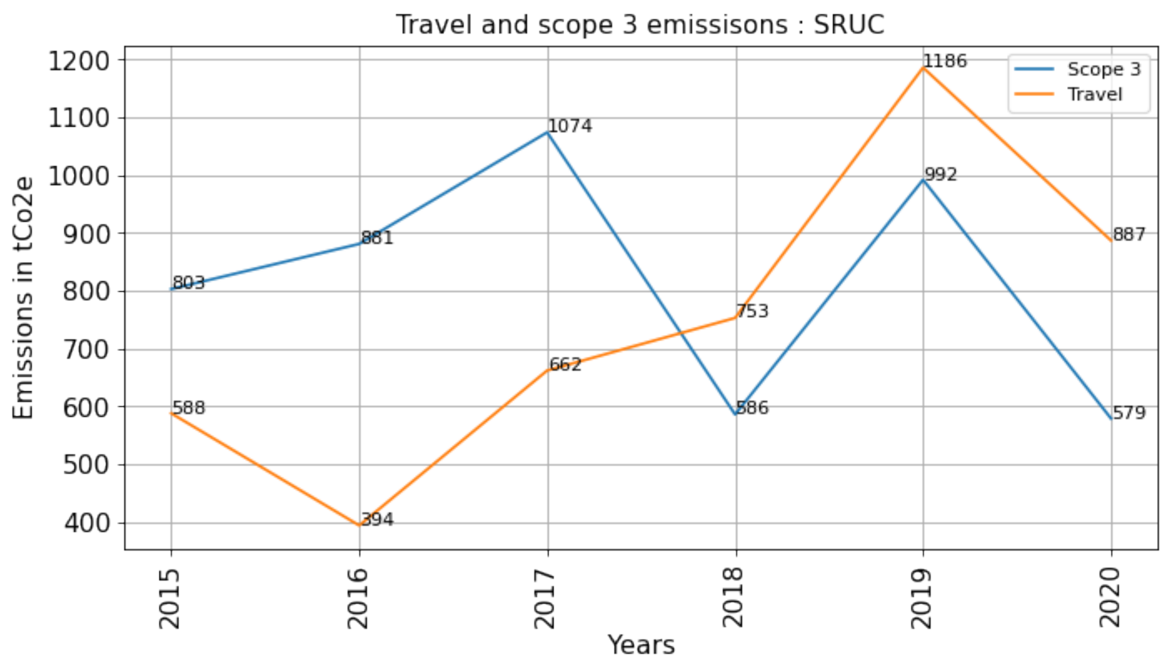


Figure 5-8: Comparison of Travel and scope 3 emissions for SRUC

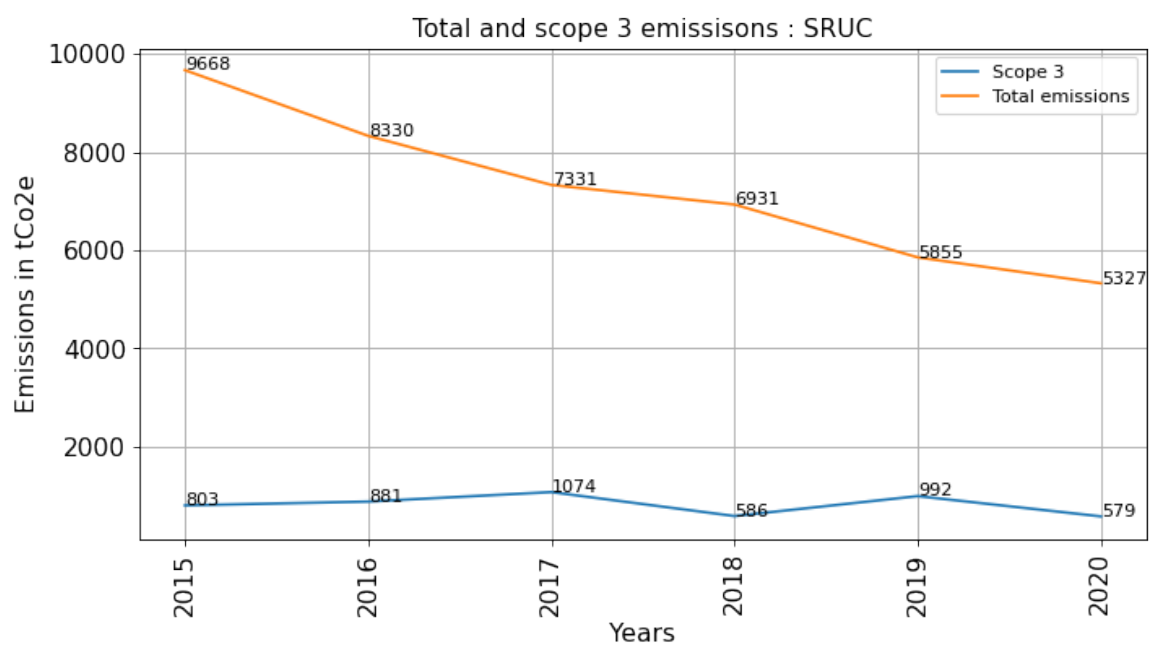


Figure 5-9: Comparison of total and scope 3 emissions for SRUC

As this cluster suggests, scope 3 emissions are a small portion of the total emissions, as shown in figure 5-9 above. This plot will change if scope 3 emissions reporting errors are rectified. The remaining HEIs within cluster 1 are RGU, University of Stirling, Abartey University, and University of West of Scotland, which did not report travel emissions in 2019.

Robert Gordon University

Table 5-5 Budget normalised emissions for Robert Gordon University

Year	Budget (GBP)	Scope 3 tCO2e	Scope 3 emissions/GBP (million)	Total emissions tCO2e	Total emissions/GBP (million)
2015	97,473,000	573	5.9	9,808	101
2016	106,842,000	594	5.6	8,924	84.2
2017	100,789,000	474	4.74	7,135	71.35
2018	100,484,000	343	3.43	6,516	65.2
2019	97,926,000	320	3.3	5,953	61
2020	105,394,000	282	2.6	5596	53.3
2021	107,065,000	204	1.9	6,089	57

According to Table 5-5, RGU and University of Aberdeen are the only HEIs where the budget has remained stagnant between 2015 and 2019. This situation is noteworthy considering both institutions are located in Aberdeen, a city dominated by the oil and gas industry. It can be inferred that the scope 3 emissions and total emissions for these HEIs are likely to be considerably higher than what is indicated in Table 5-5. This is primarily because significant components of scope 3 emissions, such as travel and commute, have not been reported.

The distribution of scope 3 emissions is depicted in the pie chart below (Figure 5-10).

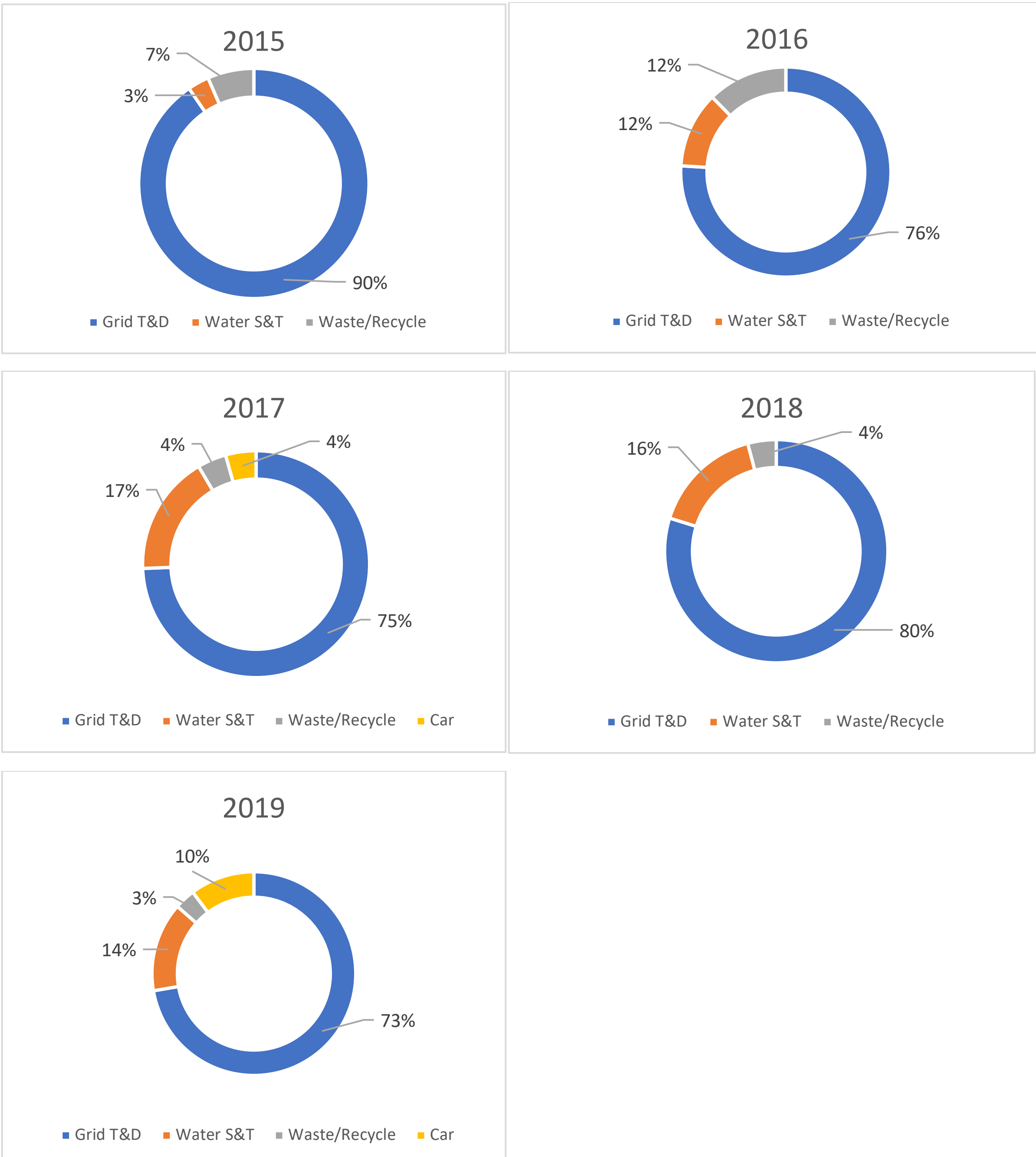


Figure 5-10: Year-wise scope 3 emission split for Robert Gordon University

Figure 5-10 provides an overview of RGU's scope 3 emissions, including grid transmission and distribution (T&D), water supply and treatment (S&T), and waste/recycling. Water S&T emissions have consistently accounted for approximately 12% to 17% of the total scope 3 emissions, while grid T&D emissions have ranged from 73% to 90% of scope 3 emissions. In 2017 and 2019, RGU reported car emissions of 4% and 10%, respectively. However, the data for car emissions was missing in the report for 2018. Furthermore, in 2018, car emissions were incorrectly accounted for in scope 1 emissions, which constitutes an error in the reporting. Throughout the period from 2015 to 2019, scope 3 emissions represented a relatively small proportion, ranging from 5% to 7% of the total emissions. Theoretically, this proportion appears to be quite low.

University of Stirling

Table 5-6 Budget normalised emissions for the University of Stirling

Year	Budget (GBP)	Scope 3 tCO2e	Scope 3 emissions/GBP (million)	Total emissions tCO2e	Total emissions/GBP (million)
2016	113,254,000	285	2.5	11,990	106
2017	117,337,000	284	2.4	11,321	96.5
2018	NA	303	NA	11,171	NA
2019	NA	1,774	NA	10,310	NA
2020	NA	1,500	NA	10,612	NA
2021	122,686,000	90	0.8	8,070	65.8

Table 5-6 reveals highly inconsistent data reported by the University of Stirling over the five-year period. The 2015 data sheet was incomplete and, therefore, could not be analyzed. Notably, the university only reported its budget for 2016 and 2017, despite the availability of budget records. Unfortunately, this data was missing from the datasheet, which presents a notable gap in the reporting. Between 2016 and 2019, the University of Stirling only recorded two categories of scope 3 emissions: water supply and treatment (S&T) and waste and recycling. Grid transmission and distribution (T&D) emissions were reported in 2016 but were not included in subsequent years' reports. The emissions from water S&T varied, with a minimum of 224 tCO2e in 2020 and a maximum of 257 tCO2e in 2018. These emissions remained relatively constant throughout the years. Due to inadequate data, no charts or visual representations were provided for the University of Stirling (UoS). It is worth noting that UoS began tracking travel emissions in 2020. However, there was a discrepancy between the total scope 3 emissions (measured at 255) and the breakdown of scope 3 emissions. When considering transport, water S&T, and waste/recycling, the total emissions amounted to 1500 tCO2e. This anomaly in the scope 3 numbers raises concerns about the accuracy and reliability of the total emissions figure, indicating low confidence in the reported value. There is significant potential for the University of Stirling to improve the reporting structure of scope 3 emissions, particularly regarding total emissions. By making minor changes to the data collection and calculation methods, the university can significantly enhance its emissions reporting accuracy.

Abertay University

The Abertay University spreadsheet from 2016 to 2020 is not comprehensive. Abertay University is not investigated further as a result of severely erroneous and missing data.

The University of West of Scotland

Table 5-7 Budget normalised emissions for the University of West of Scotland

Year	Budget (GBP)	Scope 3 tCO2e	Scope 3 emissions/GBP (million)	Total emissions tCO2e	Total emissions/GBP (million)
2015	3,211,000	1,979	659	10,273	3424
2016	107,933,000	1,422	13.2	9,014	84.2
2017	111,859,000	1,772	15.9	8,650	77.2
2018	112,328,000	1,676	14.9	8,254	73.7
2019	120,156,000	1,107	9.2	6,405	53.3
2020	121,971,000	NA	NA	Incomplete	NA

Table 5-7 indicates that the budget for the University of Stirling in 2015 was slightly over 3 million GBP, which is significantly lower than the budgets for the subsequent five years. From 2016 to 2020, the budget fluctuated within a relatively narrow range, ranging from around 107 million GBP to 122 million GBP. However, the scope 3 emissions reported by the University of Stirling are incomplete since they do not include travel and grid transmission and distribution (T&D) emissions. These two components are significant contributors to scope 3 emissions and should be included for a comprehensive emissions assessment. Throughout the years, the university consistently reported scope 3 emissions for water supply and treatment (S&T) and waste/recycling. However, these emissions constitute a minor portion of the overall emissions and may not play a substantial role in emissions reduction initiatives.

Within Cluster 1, which includes University of Aberdeen, University of Starthclyde, and SRUC, some promising emission calculations have been demonstrated. However, there is still a significant margin for improvement to achieve accurate emissions reporting. Other HEIs within this cluster have substantial work ahead to enhance their scope 3 emissions reporting. It is worth noting that while water S&T and recycling emissions were reported by all HEIs, crucial emissions such as grid transmission and distribution, as well as travel and commuting emissions, were not reported. Improving the reporting of scope 3 emissions, particularly by including key emission sources, is essential for comprehensive emissions assessments across HEIs.

5.1.2 Scope 3 emissions analysis for cluster 2

In Cluster 2, which includes University of Dundee, University of the Highlands and Islands, Heriot-Watt University, University of St Andrews and University of Edinburgh, the reported scope 3 emissions range from 20% to 40% of the total emissions. This percentage aligns reasonably well with the findings from the literature review. Among the HEIs in this cluster, University of Dundee, University of St Andrews, and University of Edinburgh are described as ancient universities. These institutions have a long history and established reputations in the higher education sector. It is important to consider these scope 3 emissions and their proportions in relation to the total emissions to gain insights into the sustainability efforts and potential areas for improvement within these HEIs.

University of Edinburgh

It is one of the earliest HEIs, and the reporting of the emissions operations is consistent and in-depth. From 2015 to 2020, it recorded commuting and travel-related emissions for staff and students. Figure 5-11, 5.12 and 5.13 shows the commute, travel, and scope 3 emissions and their relation.

Table 5-8 Budget normalised emissions for the University of Edinburgh

Year	Budget (GBP)	Scope 3	Scope 3 emissions/GBP (million)	Total emissions	Total emissions/GBP (million)
2015	840,748,000	22,140	26.35	1,07,018	127.4
2016	908,568,000	29,726	32.74	1,03,783	114.3
2017	928,847,000	34,776	34.5	1,05,914	114.1
2018	984,400,000	30,251	30.74	94,989	96.5
2019	1,102,000,000	31,106	28.2	91,391	82.9
2020	1,120,100,000	19,175	17.1	82,802	73.9
2021	1,187,000,000	6,112	5.15	69,157	58.26

The University funding has increased by 33% from 2015 to 2020 (table 5-8). During the same time, scope 3 emissions have reduced by 13.4%, and the total emissions have decreased by 41%. The University of Edinburgh climate change policy and its budget had a significant impact on scope 1&2 emissions and not so great on scope 3 emissions.

The breakdown of scope 3 emissions is shown in the pie chart below

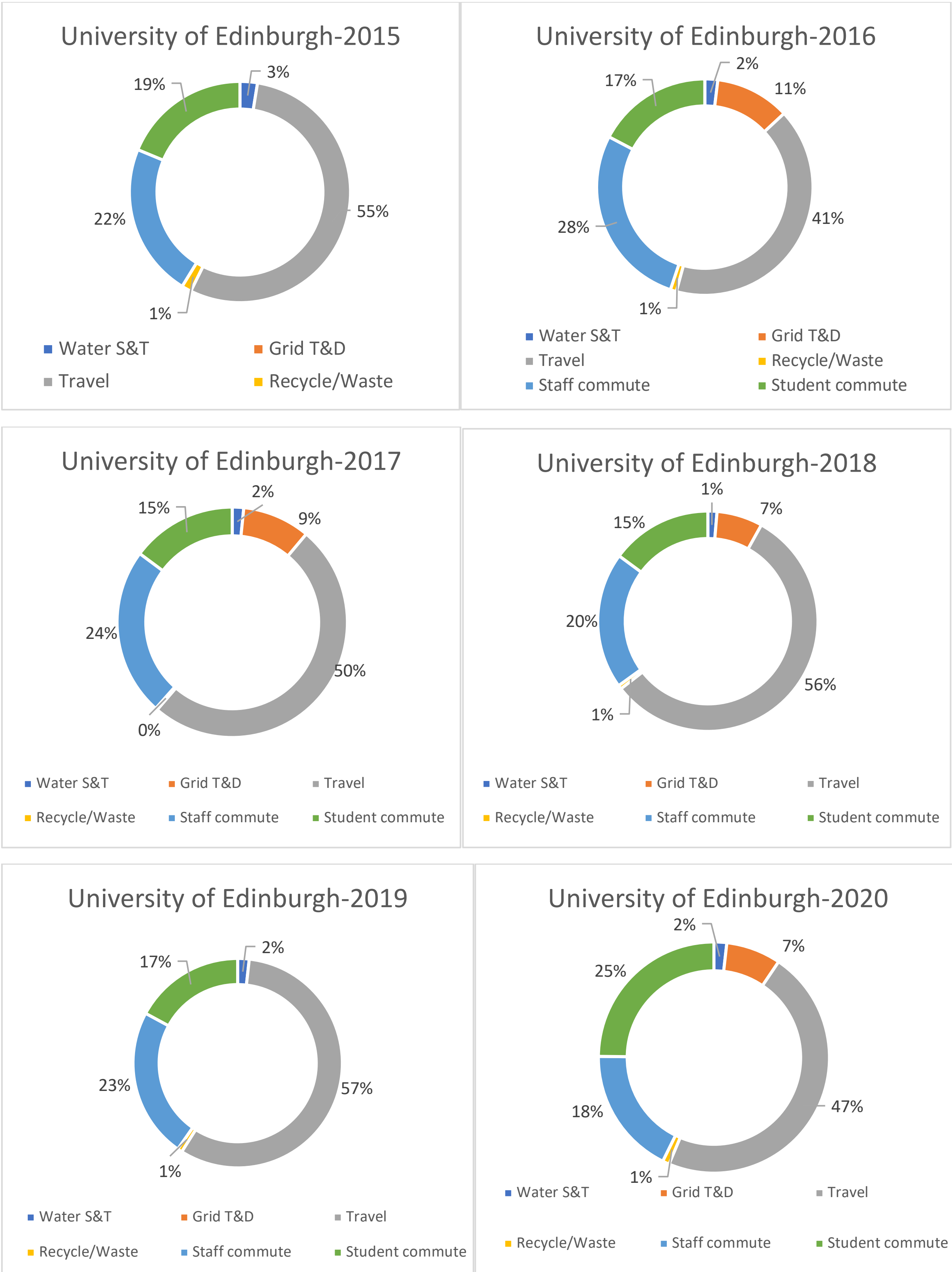


Figure 5-11: Year-wise scope 3 emissions split for Edinburgh University

According to Figure 5-11, transport emissions consistently accounted for approximately 50% of the scope 3 emissions throughout the entire six-year study period. The staff commute contributed around 25% of the total emissions, followed by the student commute at approximately 17%. When considering business travel, staff commute, and student commute together, these categories constitute 92% of the scope 3 emissions. It is worth noting that several HEIs in Cluster 1 did not report travel and commute emissions, which is a significant gap in their emissions reporting. By considering the University of Edinburgh as a benchmark, not reporting travel emissions alone would lead to a 50% reduction in scope 3 emissions. Additionally, not reporting travel and commute emissions would result in a reduction of 90% in emissions. It highlights the importance of accurately reporting these categories to obtain a comprehensive assessment of scope 3 emissions.

Regarding grid transmission and distribution (T&D), it constituted between 7% to 11% of the scope 3 emissions. However, it is important to mention that grid T&D was not reported in 2015 and 2019. Nonetheless, imputing the value for T&D can be done by multiplying the grid generation activity data by the T&D emission factor (EF). These insights emphasize the significance of reporting accurate data for travel, commute, and grid T&D emissions to ensure a comprehensive assessment of scope 3 emissions.

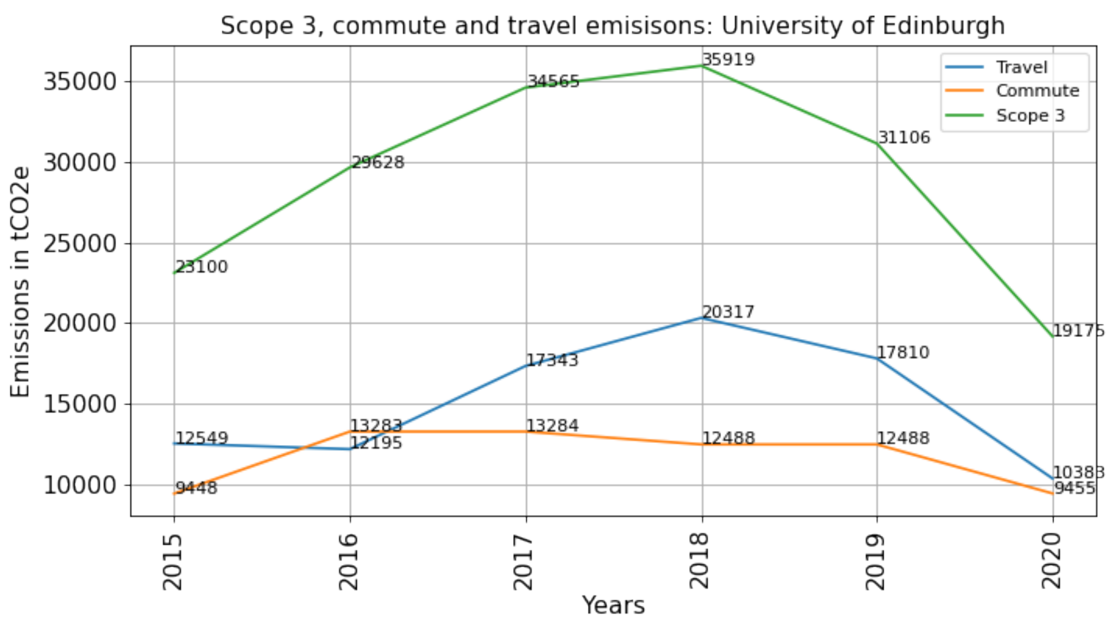


Figure 5-12: The commute and travel emissions for the University of Edinburgh

According to Figure 5-12, scope 3 emissions ranged from a low of 20% in 2015 to a high of 36% in 2018. This indicates that scope 3 emissions, particularly travel and commute emissions, constitute a significant portion of the overall emissions, accounting for more than 90% of scope 3 emissions. Therefore, it is evident that travel and commute emissions play a crucial role in the overall emissions profile. Further analysis of the travel and commute emissions reveals notable variability. Travel emissions consistently exceeded commute emissions, except for 2016 when commute emissions were marginally higher than travel emissions. The gap between travel and commute emissions was most significant in 2018.

Table 5-8 indicates that the University of Edinburgh's budget has consistently increased from 2015 to 2021. However, it is interesting to note that travel and commute emissions peaked in 2018 and have been decreasing since then. This trend suggests that efforts have been made to reduce travel-related emissions, which could be attributed to various initiatives or changes in travel practices. Additionally, the lower travel-related emissions in 2020 and 2021 can be attributed to the impact of COVID-19 lockdown measures, which restricted travel activities. It is important to continue monitoring and addressing travel and commute emissions to sustain the reduction achieved in recent years and further contribute to emission reduction goals.

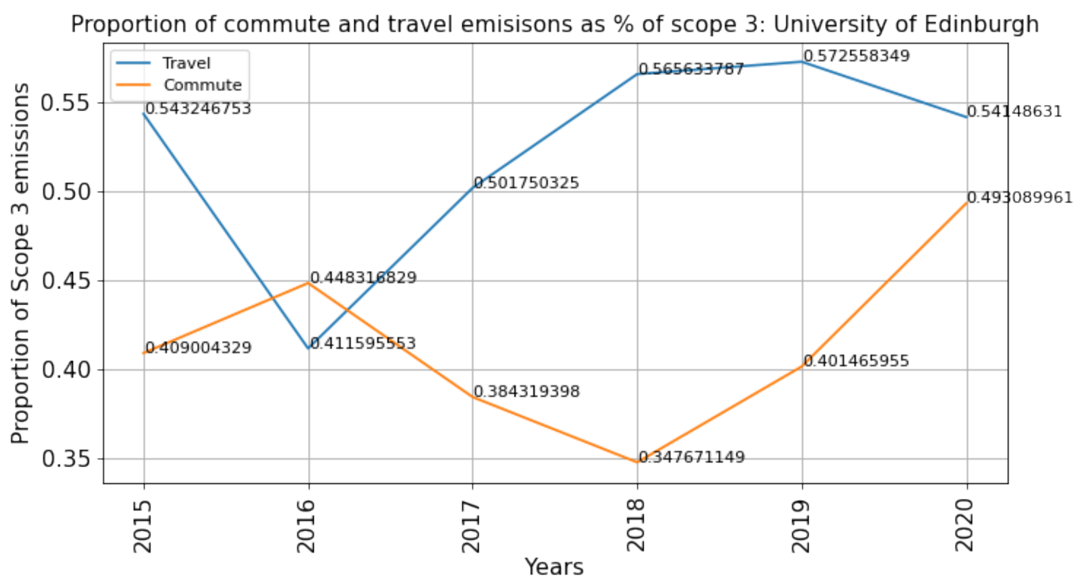


Figure 5-13: Travel and commute emissions as a proportion of scope 3 emissions

According to Figure 5-13, travel emissions in 2015 were recorded at 12,549 t CO2e. These emissions increased by 62% in 2018 and then decreased below the 2015 levels by 2020. This suggests that efforts were made to reduce travel-related emissions over the years, resulting in a decrease below the initial levels. Interestingly, there is a strong correlation between scope 3 emissions and both commute emissions and travel emissions, with a correlation coefficient of approximately 0.88. This indicates that as scope 3 emissions increase or decrease, there is a similar pattern observed in both commute emissions and travel emissions. Within the travel emissions category, long-haul flights accounted for 43% of emissions in 2018. Overall, flight-related emissions constituted 93% of the total travel emissions, while the remaining emissions were attributed to rail, taxi cars, and coaches. To address commute emissions, the University of Edinburgh conducts periodic surveys on student commuting to campus. In 2019, the survey revealed that 80% of students either walked to campus or used a bus as their mode of transportation (University of Edinburgh, 2021). This indicates positive progress in reducing commute emissions through encouraging sustainable transportation options.

Table 5-9 provides information on the target and performance of key performance indicators. Efforts to reduce travel and commute emissions, as well as promoting sustainable transportation options, are crucial for achieving emission reduction goals..

Table 5-9 Improvement in the commute emissions from 2016 to 2019: University of Edinburgh

Target	2016 Baseline	2017	2019
Walking 30% staff 60% student	25% staff 57% student	25% staff 54% student	25.5% staff 50.4% student
Cycling: 15% of staff and students (combined)	13%	13%	11.6
Car driving: 29% of staff and students at every site (except Easter Bush)		All sites achieved this except Pollock Halls	All sites achieved this except Pollock Halls

It appears that the walking and cycling goals set by the University of Edinburgh (University of Edinburgh) may not be considered particularly aggressive, considering their proximity to the baseline year. Additionally, it is evident that the university did not make significant progress in achieving the baseline year targets. Even for cycling, the targets were less ambitious and were not met until 2019.

Setting ambitious and achievable targets is crucial for driving progress and promoting sustainable modes of transportation, such as walking and cycling. It is important for institutions to regularly review and revise their goals to ensure they align with the desired outcomes and contribute to significant emissions reductions. It may be beneficial for University of Edinburgh to reassess their targets, considering more ambitious and measurable goals that can drive substantial progress in encouraging walking and cycling as sustainable modes of transportation. By doing so, the university can enhance its efforts to achieve emissions reduction targets and promote sustainable mobility options for its community..

University of Dundee

Table 5-10 Budget normalised emissions for the University of Dundee

Year	Budget (GBP)	Scope 3 tco2e	Scope 3 emissions/GBP (million)	Total emissions	Total emissions/GBP (million)
2015	240,000,000	10,149	42.3	33,471	139.5
2016	243,500,000	9,469	38.9	31,828	130.4
2017	244,400,000	8,118	33.2	28,913	118.5
2018	250,000,000	9,814	39.3	30,282	121.1
2019	256,000,000	5,945	23.22	25,599	100
2020	250,000,000	2,573	10.3	20,319	81.3
2021	275,316,000	446	1.62	19,182	69.7

According to Table 5-10, the scope 3 normalised emissions for the University of Dundee are slightly higher compared to the University of Edinburgh and Edinburgh Napier University. The University of Edinburgh's normalised emissions range from 26 to 17, while the University of Dundee's range from 42.3 to 10. Similarly, the budget-normalised total emissions for University of Dundee fall in the range of 140 to 70, slightly higher than the University of Edinburgh 's range of 127 to 71. It is worth noting that, similar to Edinburgh Napier University, University of Dundee did not report commute emissions, which significantly reduces both scope 3 and total emissions. If commute emissions were included, the budget-normalised emissions (both scope 3 and total) for University of Dundee would likely be even higher than those of University of Edinburgh. In 2020, there was a marginal reduction in scope 3 emissions for University of Dundee. However, the budget consistently increased year-on-year. It can be challenging to explain how the funds were allocated during the lockdown period when there were no emissions-related activities taking place. It would require further investigation and clarification to understand the allocation of funds during that time. The discrepancies in emissions and budget allocation during the lockdown period highlight the need for transparency and clear reporting practices to ensure accurate understanding and assessment of emissions and resource utilisation.

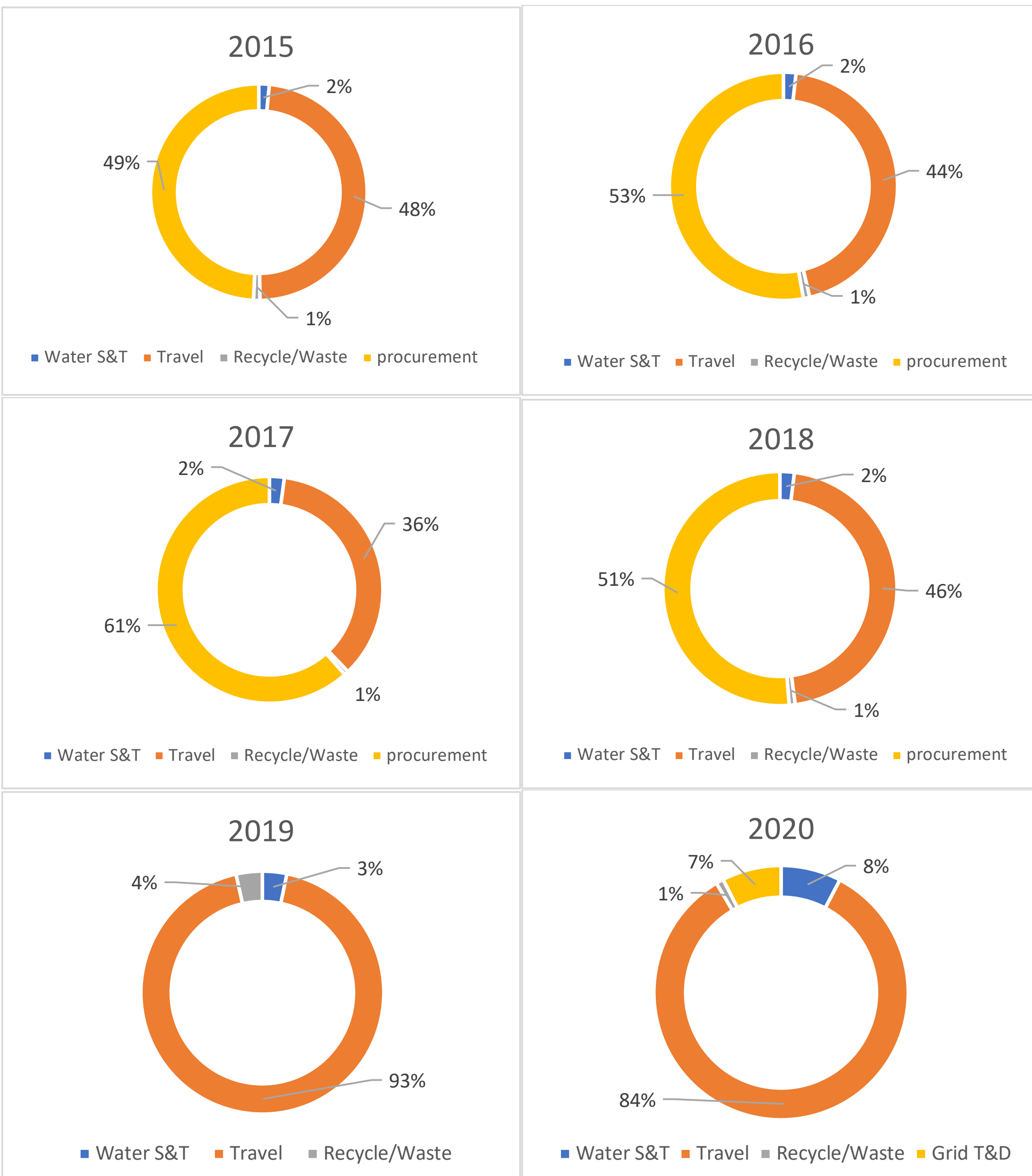


Figure 5-14: Year-wise scope 3 emission split for the University of Dundee

The University of Dundee reported four main components of scope 3 emissions: water supply and treatment (S&T), travel, recycling/waste, and grid transmission and distribution (T&D). However, the reporting of these components was not consistent across the years. One important activity included in the breakdown of scope 3 emissions was procurement emissions. However, the comments in the SSN data suggest that the university does not have sufficient knowledge to calculate procurement emissions. As a result, the reported procurement emissions remained unchanged at 5000 tCO_2e from 2015 to 2019. Since procurement emissions constitute a significant portion of scope 3 emissions and have remained constant over the years, it has influenced the distribution of scope 3 emissions across different components. Adding to the complexity, grid transmission and distribution emissions were reported only in 2020, constituting 7% of the scope 3 emissions. Travel emissions accounted for less than 50% of scope 3 emissions when procurement emissions were included. The travel emissions in 2019 and 2020, when procurement emissions were not recorded, were consistent with those of University of Edinburgh and Edinburgh Napier University, representing over 80% of scope 3 emissions. However, there was significant fluctuation in the travel emissions numbers, as shown in Figure 5-15 below. Travel-related emissions were halved in 2017, doubled in 2019, and reached their lowest level in 2020. This high variance in travel emissions suggests potential flaws in the reporting process.

In contrast, there was not much variation in water S&T and recycling/waste-related emissions, indicating more consistent reporting in these categories. The complexities and inconsistencies in reporting, particularly regarding procurement emissions and travel-related emissions, highlight the need for accurate and transparent reporting practices to ensure a comprehensive assessment of scope 3 emissions.

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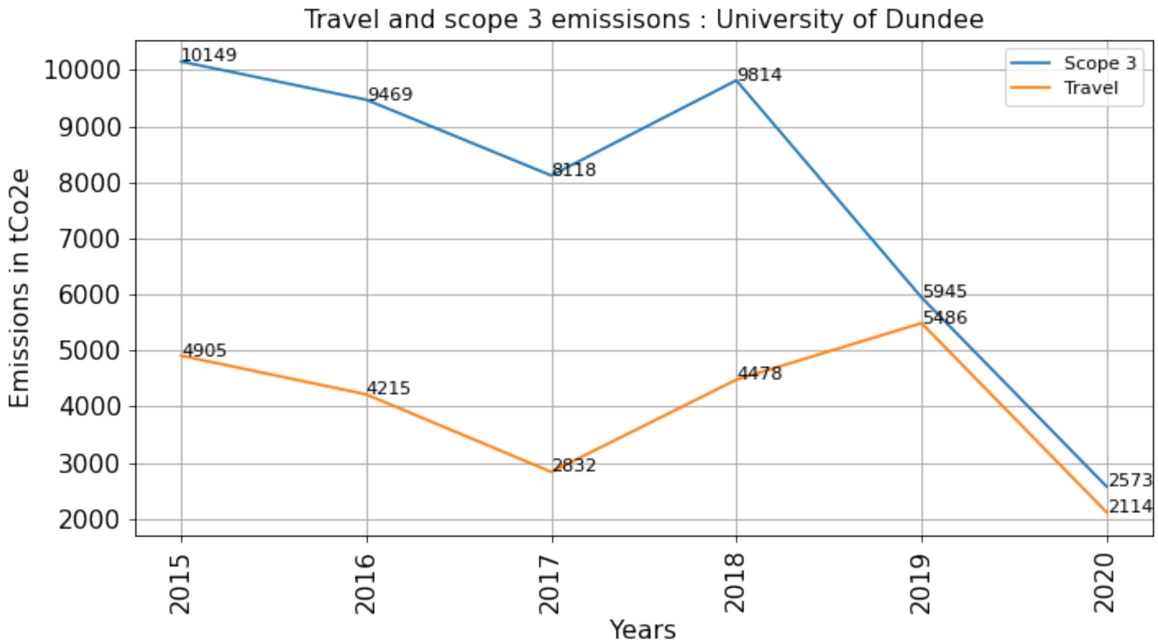

Figure 5-15: Travel and scope 3 emissions for the University of Dundee

St Andrews University

St Andrews is one of the oldest Universities in the United Kingdom, with ancient building structures spread across a wide area. Scope 3 emissions were slightly more than 20% of the total emissions across the six years. The annual budget normalised scope 3 emissions and total emissions, as shown in Table 5-11 below.

Table 5-11 Budget normalised emissions for St Andrews University

Year	Budget (GBP)	Scope 3	Scope 3 emissions/GBP (million)	Total emissions	Total emissions/GBP (million)
2015	212,406,000	9,437	44.5	33,089	156.1
2016	221,386,000	8,781	39.7	30,598	138.5
2017	229,991,000	7,618	33.3	25,854	112.9
2018	251,913,000	8,476	33.8	22,789	90.8
2019	257,448,000	7,098	27.6	22,057	85.8
2020	261,376,000	62,421	239.2	73,877	283
2021	290,387,000	35,758	123	50,318	173

According to the data provided, the budget-normalised scope 3 emissions for St Andrews University are nearly double those of the University of Edinburgh. However, the budget-normalised total emissions are very close between the two universities. The budget-normalised emissions serve as a measure of how effectively the budget has contributed to emissions reductions. Scope 3 emissions consistently account for approximately 30% of the total emissions, except in 2020 when there is a significant increase in emissions due to the inclusion of additional activities, particularly procurement and construction emissions. In 2020, scope 3 emissions constituted 84.5% of the total emissions. This highlights the importance and impact of calculating comprehensive scope 3 emissions. It demonstrates the significance of considering the full range of activities and their emissions contributions for a comprehensive understanding of the university's environmental impact. From 2015 to 2020, there was a marginal increase in the budget (23%) with a proportional change in scope 3 emissions. However, the overall emissions decreased by 33% from 2015 to 2019. This indicates that the budget was more successful in reducing direct emissions during the same time frame. The six pie charts provided represent the broad activities described under scope 3 emissions (Figure 5-16). These charts illustrate the distribution of emissions across different activities within the scope 3 category. It is important for universities to continue monitoring and addressing scope 3 emissions to effectively reduce their overall environmental impact. By considering a comprehensive range of emission sources and implementing targeted strategies, universities can make significant progress in achieving their emissions reduction goals. (figure 5-16).

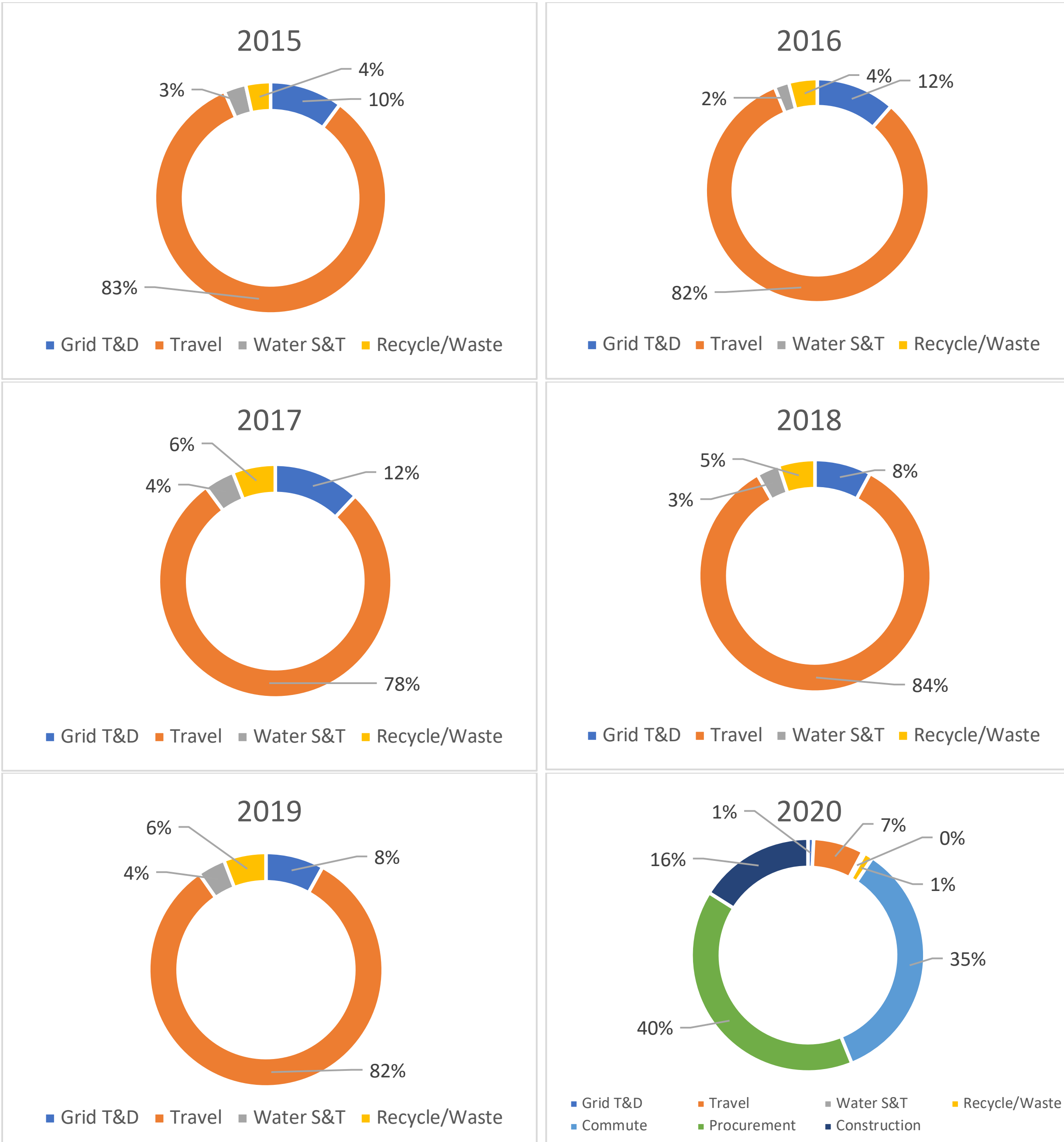

Figure 5-16: Year-wise scope 3 emission split for St Andrews University

According to the information provided, St Andrews University has consistently reported emissions from water supply and treatment (S&T), grid transmission and distribution (T&D), travel, and waste and recycling for six years. Over this period, grid T&D emissions have decreased by 50%, while travel emissions have reduced by 45%. For the first five years (2015 to 2019), travel emissions consistently accounted for over 80% of the scope 3 emissions, except for 2017 when it was 78%. Emissions from water S&T remained the same throughout the six-year period. Recycling and waste emissions doubled from 2015 to 2020. However, as they only make up a small portion (around 5%) of the scope 3 emissions, these improvements have limited overall impact on scope 3 emissions reduction. In 2020, St Andrews University decided to include three additional scope 3 emissions sources: commute, procurement, and construction emissions. The inclusion of these components resulted in a significant increase in scope 3 emissions by nine times and total emissions by 3.5 times. Travel emissions, which previously constituted 80% of scope 3 emissions, now make up only 7%. Among the newly included emissions, procurement was the primary source (40%), followed by commute emissions (35%), and construction emissions (16%). Within the commute emissions, student commutes accounted for 90% of the total.

It is important to note that emissions from construction and procurement were estimated without activity and emission factor (EF) data. Consequently, there is substantial uncertainty associated with the scope 3 emissions for 2020 due to these assumptions. Despite this uncertainty, the data demonstrates the impact of including all procurement-related carbon emissions sources in scope 3 reporting. In Cluster 2, the University of Edinburgh has also recorded commute and travel emissions, with commute emissions accounting for 25% and travel emissions for 50%. In contrast, St Andrews University has 40% commute emissions and 6% travel emissions. These datasets can be used to assess the potential impact of including procurement and construction emissions for the University of Edinburgh and to analyze the resulting step change in emissions values. Accurate reporting and comprehensive inclusion of emissions sources are crucial for universities to understand their environmental impact and implement effective emission reduction strategies.

Heriot-Watt University

Table 5-12 Budget normalised emissions for Heriot-Watt University

Year	Budget (GBP)	Scope 3	Scope 3 emissions/GBP (million)	Total emissions	Total emissions/GBP (million)
2015	146,357,545	4,566	31.2	21,584	147.8
2016	157,161,667	4,590	29.2	20,414	130
2017	164,649,023	4,933	30.1	20,059	121.5
2018	172,535,027	4,827	28	18,789	108.6
2019	172,535,027	4,543	26.3	17,474	82
2020	172,535,027	2725	15.7	14,092	81.7
2021	179,335,482	996	5.5	11,362	63.3

Based on the information provided, the budget-normalised scope 3 and total emissions for Heriot-Watt University are relatively lower compared to the University of Edinburgh and St Andrews University. This is because Heriot-Watt University includes commute emissions in their reporting, as mentioned in Table 5-12. Over a five-year period, the university's funding increased marginally by 17%. However, there has been a significant decrease of 50% in scope 3 emissions during the same period, which is proportional to the decrease in total emissions (-44%). It indicates that efforts have been made to reduce emissions, resulting in a significant decline in both scope 3 and total emissions.

During the COVID-19 lockdown period, there was a step change in scope 3 emissions, with a reduction of 40%. In contrast, the total emissions decreased by only 20%. This suggests that fuel and electricity consumption (scope 1 and 2 emissions) did not reduce significantly during the lockdown period. The unusually high total emissions observed during this time could be attributed to estates negligence or potential errors in recording. It is crucial for the university to investigate the factors contributing to the high total emissions during the lockdown period to ensure accurate and reliable reporting. Additionally, ongoing efforts to reduce emissions should focus on identifying opportunities for energy conservation and efficiency measures, as well as promoting sustainable commuting options to further decrease scope 3 emissions.

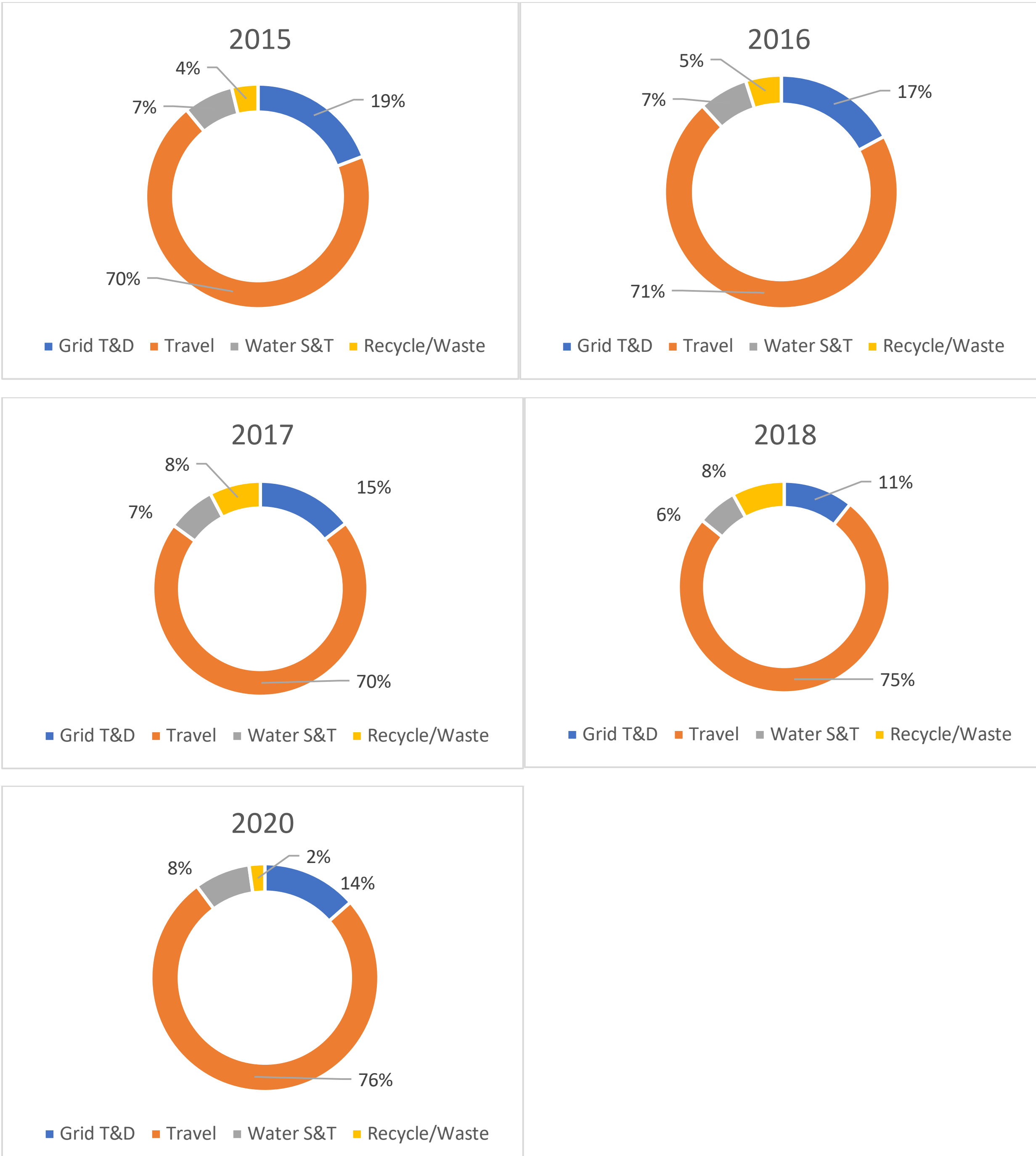

Figure 5-17: Year-wise scope 3 emission split for Heriot-Watt University

The emission split for St Andrews University remains relatively consistent across the years. Travel emissions consistently account for approximately 70% to 76% of the scope 3 emissions, making it the largest contributor. The second largest emitter is grid transmission and distribution, contributing in the range of 11% to 19% of the scope 3 emissions. Water S&T and waste and recycling are the other two sources of scope 3 emissions reported consistently for all the years. This consistent emission split suggests that travel emissions and grid T&D emissions are significant contributors to St Andrews University's overall scope 3 emissions profile. It highlights the importance of addressing these areas to effectively reduce the university's environmental impact. By focusing on sustainable transportation options and energy efficiency measures in grid T&D, the university can make targeted efforts to reduce emissions in these key areas. Additionally, ongoing waste management and recycling initiatives can contribute to emissions reduction associated with waste and recycling activities. Consistency in reporting across the years provides a valuable basis for monitoring progress and identifying opportunities for further emissions reductions in the future.

University of Highland and Island

University of Highland and Island is a very small HEI compared to the other HEIs within cluster 2. Nevertheless, it has reported scope 3 emissions in the range of 20% to 40%. During the study period, scope 3 emissions have decreased by 28% although the university budget has increased by 30% between 2015 and 2020. (Table 5-13). Despite this, overall emissions rose by 42% in the same year. It may be deduced from the statistics that there is a sizable underreporting of scope 3 emissions when compared to University of Edinburgh and St Andrews University. The total emissions and the budget normalised scope 3 are on the lower side, casting doubt on the accuracy of the data.

Table 5-13 Budget normalised emissions for the University of Highland and Island

Year	Budget (GBP)	Scope 3	Scope 3 emissions/GBP (million)	Total emissions	Total emissions/GBP (million)
2016	10,300,000	121	12.1	291	29.1
2017	7,700,000	69	9.8	296	38.4
2018	10,700,000	86	8.6	570	53
2019	135,000,000	125	0.9	518	3.8
2020	136,004,002	86	0.63	498	38.3
2021	135,532,000	111.8 (includes 95.7*)	0.83	428 (Includes 95.7*)	3.16

(*95.7 tCO2e for homeworking)

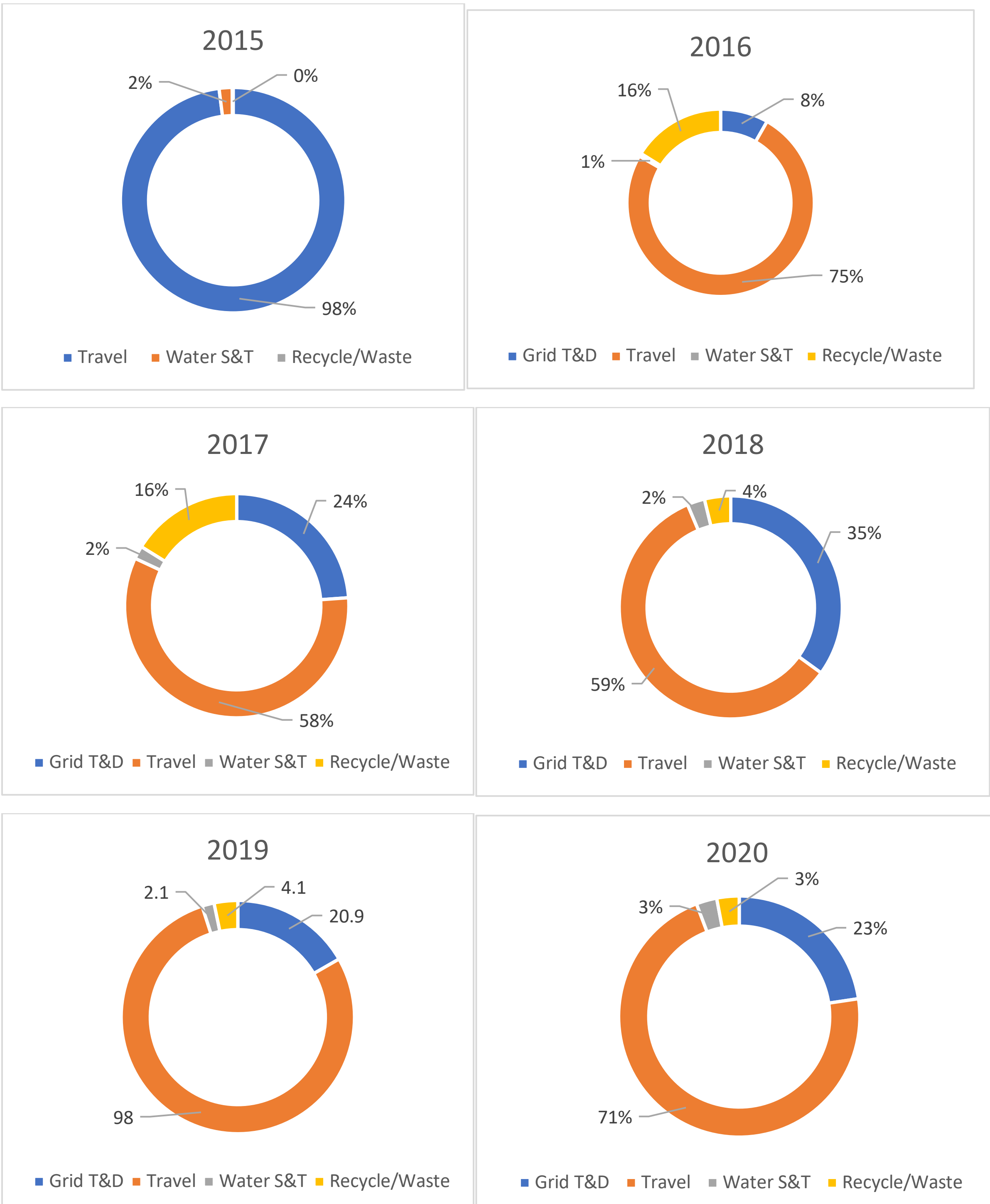

Figure 5-18: Year-wise scope 3 emission split for the University of Highland and Island

The grid T&D emissions were documented from 2016 to 2020 but were not reported for 2015. This absence of data for 2015 results in a significant difference in the pie chart compared to the other years, as depicted in Figure 5-18. The percentage contribution of travel emissions exhibits substantial variability, ranging from a low of 58% to a high of 98%. This indicates significant fluctuations in the relative importance of travel emissions compared to other emission sources. Grid T&D emissions also show a high variance, ranging from 8% to 35%, reflecting inconsistencies in their contribution over the years. Water S&T and recycling and waste emissions appear to have negligible contributions, suggesting they have a minimal impact on the overall scope 3 emissions for St Andrews University. It is worth noting that commute and procurement emissions were not reported, which means their contributions are not reflected in the pie chart. This omission likely affects the overall understanding of scope 3 emissions, as these emissions sources can potentially have a substantial impact on the emissions profile.

The variability observed in the pie chart underscores the importance of consistent and comprehensive reporting, including all relevant emission sources. This enables a more accurate assessment of the university's environmental impact and supports effective emission reduction strategies.

5.1.3 Scope 3 emission analysis for cluster 3

The HEIs within Cluster 3 reported emissions ranging from 40% to 60%. The University of Edinburgh and St Andrews University provided relatively comprehensive data, excluding procurement and commuting emissions. The contribution of Scope 3 emissions in these two HEIs ranged from 20% to 40%. In 2020, St Andrews University's Scope 3 emissions accounted for 84% of the total emissions, including procurement and commuting emissions. The HEIs analyzed in Cluster 3 include Edinburgh Napier University, University of Glasgow, and Queen Margaret University.

Edinburgh Napier University

Table 5-14 Budget normalised emissions for Edinburgh Napier University

Year	Budget (GBP)	Scope 3	Scope 3 emissions/GBP (million)	Total emissions	Total emissions/GBP (million)
2015	119,000,000	3,183	26.7	10,052	84.5
2016	117,000,000	4102	35.1	9591	81.9
2017	122,000,000	3498	28.7	8363	68.5
2018	121,400,000	2924	24.2	7370	60.9
2019	122,535,374	2625	21.5	6423	52.6
2020	126,674,000	1327	10.5	4559	36.2
2021	128,734,000	509 (includes 389*)	3.95	3523 (includes 389*)	27.4

The normalised Scope 3 values for the University of Edinburgh and Edinburgh Napier University are nearly similar (Table 5-14). For the University of Edinburgh, it ranged from 26 to 17, while for Edinburgh Napier University, it ranged from 27 to 10. Edinburgh Napier University has experienced a more significant reduction than the University of Edinburgh in recent years. However, there are differences in the normalised total emissions values between Edinburgh Napier University and the University of Edinburgh. For the University of Edinburgh, the budget-normalised total emissions ranged from 127 to 74, whereas for Edinburgh Napier University, it ranged from 85 to 36. The higher budget-normalised total emissions for the University of Edinburgh can be attributed to their detailed reporting of travel and commuting emissions.

Nevertheless, it remains unclear why the budget-normalised Scope 3 emissions are similar for the University of Edinburgh and Edinburgh Napier University. As of 2019, the total number of students at the University of Edinburgh is nearly three times that of Edinburgh Napier University. Figure 4.31 below illustrates how Scope 3 emissions were distributed among its components.

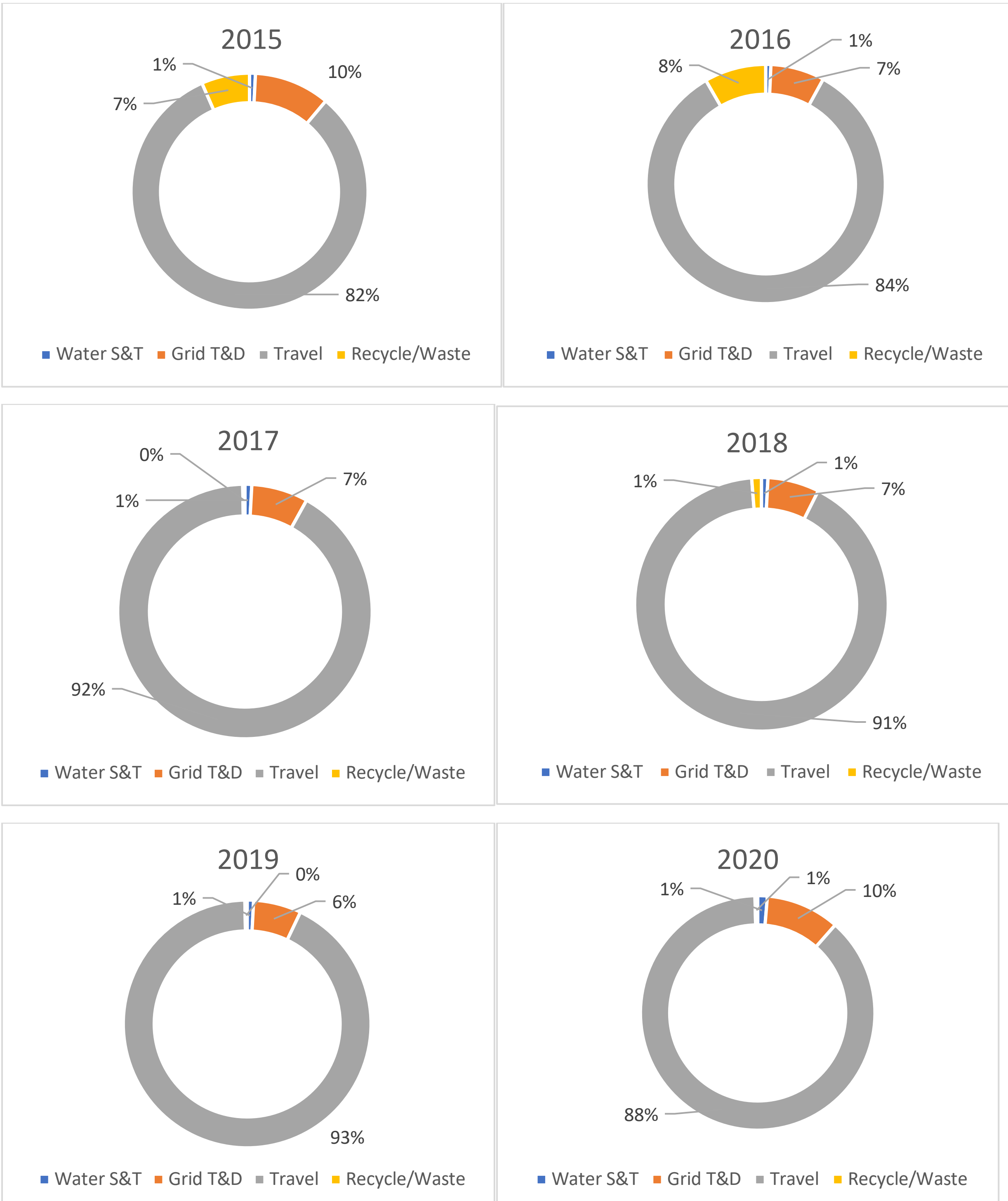

Figure 5-19: Year-wise scope 3 emission split for Edinburgh Napier University

Figure 4.31 provides an overview of the major contributors to Scope 3 emissions, including water S&T, recycling & waste, grid T&D, and travel emissions. Among these, travel emissions accounted for 82% to

92% of the total, followed by grid T&D at 6% to 10%. The remaining emissions were attributed to water S&T and recycling/waste. According to Table 4.23, Scope 3 emissions have been reduced by more than 58%. All components of Scope 3 emissions exhibited proportional reductions from 2015 to 2020, with travel emissions alone being reduced by over 60%.

However, the absence of commute emissions data limits a comprehensive understanding of the emissions landscape. Figure 5-20 illustrates the contribution of travel emissions within Scope 3 emissions. It demonstrates that travel emissions and Scope 3 emissions have been moving in tandem throughout the years. To achieve significant reductions in total emissions, ENU should prioritise efforts to reduce travel emissions while also starting to report commute emissions. This would provide a more complete picture of their emissions profile.

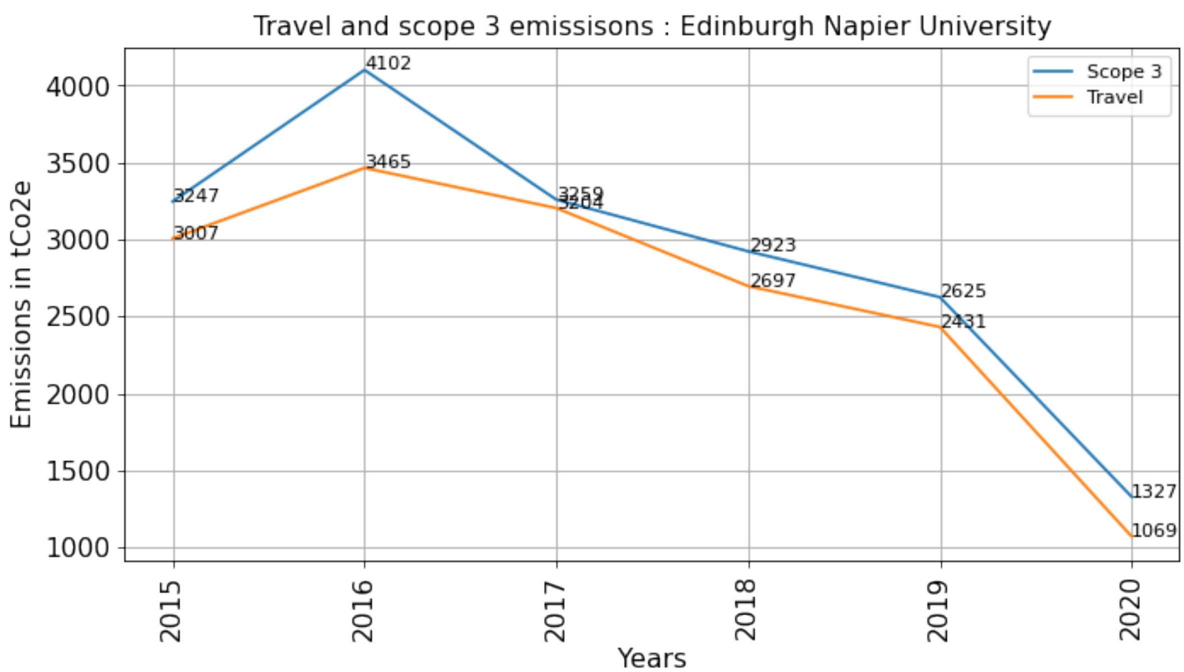

Figure 5-20: Comparison of travel and scope 3 emissions for Edinburgh Napier University

University of Glasgow

Table 5-15 Budget normalised emissions for the University of Glasgow

Year	Budget (GBP)	Scope 3	Scope 3 emissions/GBP (million)	Total emissions	Total emissions/GBP (million)
2015	511,341,000	18,411	36	64,421	126
2016	582,552,000	24,257	41.7	69,590	119.6
2017	607,843,000	23,207	38.2	64,109	105.6
2018	630,600,000	25,579	40.6	61,484	97.6
2019	687,900,000	25,502	37.1	60,358	87.9
2020	690,100,000	15323	22.2	46,785	67.8
2021	813,100,000	4257 (includes 1843*)		33,558 (includes 1843*)	

*Homeworking emissions 1843 tCO_2e

According to Table 5-15, the normalised Scope 3 emissions for the University of Edinburgh have consistently decreased over the six-year period. However, for the University of Glasgow, the normalised emissions have fluctuated within the range of 41.7 to 22.2. No clear trend in normalised emissions is observed, despite a consistent increase in the budget over the years. From 2015 to 2020, the budget of the University of Glasgow increased by 35%. These findings suggest that there may be inconsistencies in the reporting of emission activities at the University of Glasgow. It is possible that the University of Glasgow is still in the process of learning and refining its methods for calculating Scope 3 emissions. On the other hand, both universities show a clear reducing trend in normalised total emissions, similar to the University of Edinburgh.

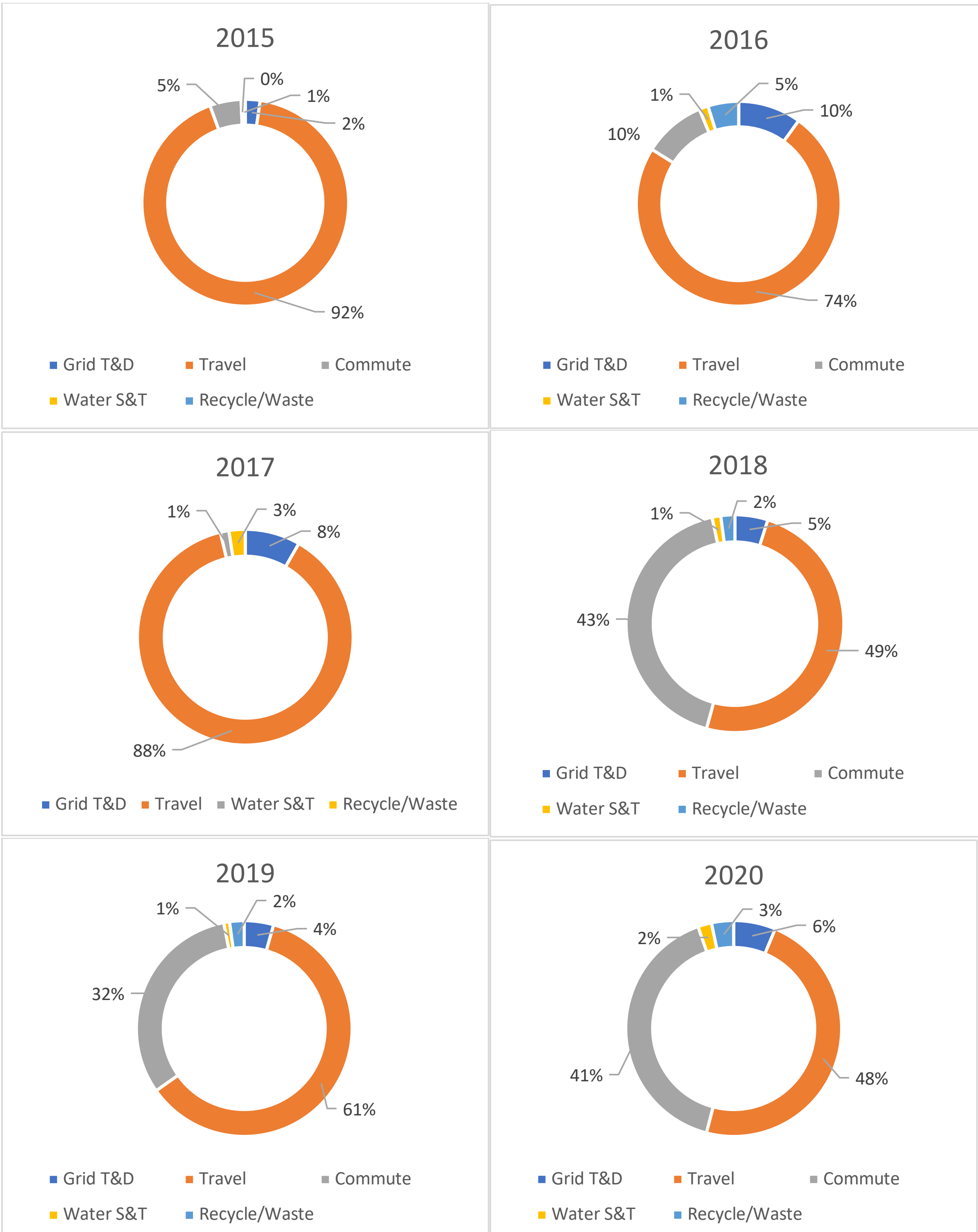

Figure 5-21: Year-wise scope 3 emission split for the University of Glasgow

Figure 5-21 highlights the five primary sources of emissions for the University of Glasgow, namely grid T&D, travel, commute, water S&T, and recycling waste. However, in 2017, the university did not declare its commute emissions. In the subsequent years when commute emissions were measured, significant variation was observed, ranging from a minimum of 2,388 tCO2e in 2016 to a maximum of 10,847 tCO2e in 2018. The high variability in commute emissions has also affected the consistency of the travel emissions data. The percentage contribution of travel emissions to the total emissions fluctuated from 92% in 2015 to 48% in 2020, likely due to the inconsistent inclusion of commute emissions in the calculation. On the other hand, the grid T&D emissions showed a consistent downward trend, decreasing from 2,494 tCO2e in 2015 to 965 tCO2e in 2020.

Queen Margaret University

There is ambiguity regarding whether QMU should be classified in clusters 1 or 3. In most years, except for 2019, the Scope 3 emissions accounted for less than 10% of the total emissions. However, in 2019, it constituted 56% of the total emissions. Since the clustering was based on the data from 2019, QMU is categorised in cluster 3. Otherwise, its emission behavior aligns more closely with cluster 1.

Table 5-16 Budget normalised emissions for Queen Margaret University

Year	Budget (GBP)	Scope 3	Scope 3 emissions/GBP (million)	Total emissions	Total emissions/GBP (million)
2015	36,183,000	11	0.3	1744	48.44
2016	37,194,000	60	1.6	2380	64.3
2017	39,152,000	50	1.3	1780	45.6
2018	36,974,000	58	1.6	1978	53.5
2019	39,518,000	1744	43.6	3098	77.5
2020	40,606,000	126	3.15	1553	38
2021	43,562,000	2309 (includes 2215*)	53	3441 (includes 2215*)	79

Table 5-17 Year-wise scope 3 emissions split for Queen Margaret University

QMU	2015	2016	2017	2018	2019	2020
Grid T&D	123		132	97.2	86.3	71.3
Water S&T	11.3	60.3	50	55	62	51
Recycle/waste		72	4.1	3	4.4	4
Travel					96.8	
Commute					1493	

The normalised Scope 3 emissions for Queen Margaret University exhibited high volatility and fluctuated between 0.3 and 43.6 without a clear trend, as indicated in Table 5-16. Similarly, the normalised total emissions displayed the same behavior, ranging from 38 to 77.5 without a specific direction. This lack of consistent trends suggests inconsistencies in the reporting of emissions. In 2015, the budget normalised emissions were very low because only grid T&D and water S&T were reported, as shown in Table 5-18. However, in subsequent years, Queen Margaret University disclosed two sources of Scope 3 emissions in 2015 and 2016, and three sources in 2017 and 2018 (grid T&D, water S&T, and recycle/waste). In 2019, the university reported five different emission sources, including travel and commuting. Notably, commuting accounted for 85% of the Scope 3 emissions, while travel represented 5%. It is important to note that when comparing travel emissions with other HEIs, there may be considerable differences in the percentage split. This discrepancy arises because Queen Margaret University primarily focuses on arts and has minimal emphasis on engineering and the sciences, making direct comparisons less meaningful..

Glasgow Caledonian University

Table 5-18 Budget normalised emissions for Glasgow Caledonian University

Year	Budget (GBP)	Scope 3	Scope 3 emissions/GBP (million)	Total emissions	Total emissions/GBP (million)
2015	120,700,000	19,407	161	26,391	219
2016	116,300,000	18,136	156	25,832	222
2017	116,285,000	16,160	139	23,217	200
2018	114,300,000	18,099	158	24,569	215
2019	120,000,000	13,887	116	20,437	170
2020	124,000,000	11,322	91	17,456	141
2021	124,000,000	11,280 (includes 11,126*)		16,852 (includes 11,126*)	

(* includes emissions from home working – 400 tCO2e and supply chain 10,720 tCO2e)

The normalised Scope 3 and total emissions for the first four years did not exhibit any clear trend, as shown in Table 5-19. However, there was a reduction in normalised emissions for 2019 and 2020. In 2015, Glasgow Caledonion University did not report travel emissions. It began reporting both travel and commute emissions in 2016 and 2017, which were similar and obtained from the same data source. In 2018, a significant primary emission source was observed in buses, totaling 5,184, which accounted for 28% of the Scope 3 emissions. This emission is categorised as student commute. The emission factor associated with this category is quoted as 0.12 Kg CO2e/Passenger Km.

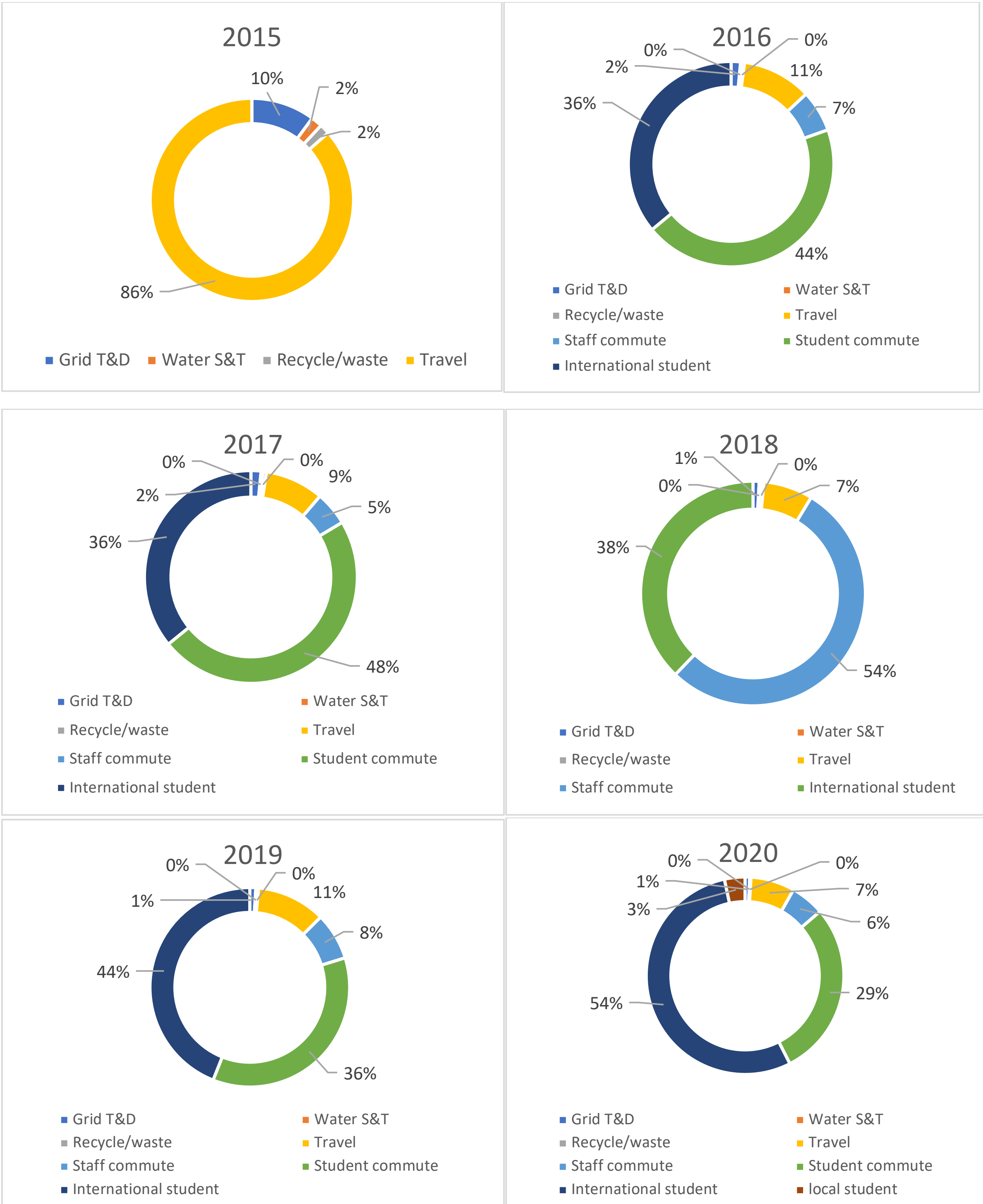

Figure 5-22: Year-wise scope 3 emission split for Glasgow Caledonian University

Figure 5-22 illustrates that Glasgow Caledonian University has made steady improvements in its reporting structure, increasing the number of emission sources from four in 2015 to eight in 2020. GCU is the only university in Scotland that reports on both domestic and international student travel. International student trips form a significant component of Scope 3 emissions, ranging from 36% to 54% of the total. The commute is identified as the most significant contributor to Scope 3 emissions, followed by international student travel. This data emphasises the importance of reporting and considering travel-related emissions, including business travel and commute, when assessing the overall emissions profile of an institution. By reporting these emissions sources, GCU demonstrates its commitment to transparency and understanding the impact of travel-related activities on its emissions.

5.2 Scope 3 emission benchmark metrices in SSN

The SSN report utilises various metrics to measure emission reduction performance, including Full-Time Equivalents (FTE), floor area, budget, etc. These metrics are used as benchmarks after normalisation with emission data. Among the HEIs, twelve out of seventeen reported floor area as the benchmark matrix, eight reported student FTE, and four reported the absolute carbon emissions target. Scope 3 emissions are normalised with the number of student FTE to enable comparisons of scope 3 emissions reporting. The resulting metric is scope 3 emissions per student. The University of Stirling, The University of Strathclyde, Robert Gordon University, the University of the Highlands and Islands, and the University of the West of Scotland had the lowest scope 3 emissions per student, less than 0.1 tCO2e. On the other hand, the University of Glasgow and Glasgow Caledonian University had the highest scope 3 emissions per student, with 0.96 and 0.97 tCO2e per student, respectively. The ratio of female to male students for the top 50% HEIs and the bottom 50% HEIs is reported as 1.44 and 1.48, respectively, which is considered insignificant. Among the HEIs, only the EU exclusively reported student commuting emissions, which accounted for 17% of the total scope 3 emissions. Queen Margaret University did not report student commuting emissions for 2019 but began logging them in 2020, with 72% of scope 3 emissions attributed to student commuting. HESA data indicates that only 20% of students stayed in HEI accommodations, suggesting that 80% of students likely engage in some form of commuting to attend university. To validate this hypothesis, HEIs need to account for student commuting emissions. HEIs such as SRUC, University of Edinburgh, St Andrews University, University of Glasgow, and Glasgow Caledonian University have the highest scope 3 emissions per student, ranging from 0.66 tCO2e to 0.97 tCO2e per student. Conversely, the University of the Highlands and Islands, the University of the West of Scotland, and Glasgow

Caledonian University have the highest proportion of students staying off-campus, with scope 3 emissions per student below 0.05 tCO_2e.

5.3 Relationship between the age of the HEI and the emissions performance

Over the past few decades, there has been a growing knowledge of the effects of climate change. However, many HEIs that were constructed in previous centuries were not designed with a focus on energy conservation. These older HEIs often have large areas and ancient architectural structures, which require excessive heating compared to modern buildings. Retrofitting these structures to improve energy performance is an option available to HEIs, although the degree of retrofitting varies among institutions.

In this section, Scottish HEIs are clustered based on their foundation year. The oldest universities, collectively referred to as the Ancient University, include the University of St Andrews (founded in 1413), the University of Glasgow (founded in 1451), the University of Aberdeen (founded in 1495), and the University of Edinburgh (founded in 1583). The University of Dundee, founded in 1881 but with unique circumstances due to mergers and late university granting status, may not always be classified as an ancient university. Table 5-20 provides the classification of HEIs based on their foundation year and corresponding scope 3 statistics.

Table 5-19 Classification of HEI based on the foundation year

HEI classification	Founded year range	HEIs included	Average internal area (m2)	Scope 3 emissions per internal area
Cluster 1	1400-1800	University of St Andrews (40) University of Glasgow (38) University of Aberdeen (37) University of Edinburgh (37) University of Strathclyde (22)	446,537	26.7 tCO2e/m2
Cluster 2	1801-1900	Heriot-Watt University (25) Queen Margaret University (14) University of Dundee (39) Glasgow school of art (10) University of highland and island (10) SRUC (19)	139,944	19.14 tCO2e/m2
Cluster 3	1900-Present	Edinburgh Napier University (24) The University of Stirling (19) The University of the West of Scotland (10) Robert Gordon University (7) Glasgow Caledonian University (49) Abertay University (7)	111,634	31 tCO2e/m2

The top 5 HEIs with the highest average gross internal area include the four Ancient Universities, along with the University of Strathclyde in 3rd position. Cluster 1, comprising the Ancient Universities, has an average gross internal area of 446,537 square meters, more than three times that of Cluster 2. The scope 3 reporting for Cluster 1 HEIs is comprehensive, with an average of 35 reported activity data, including emissions from travel and commuting. The number of reported activities remained consistent within this cluster. Cluster 2, on the other hand, has a significantly lower average internal area of 139,944 square meters, with a mean scope 3 emissions per internal area of 19.14 tCO_2e/m^2. The average number of activities reported in Cluster 2 was 20, with the University of Dundee reporting the highest number of activities (39) and the Glasgow School of Art and the University of the Highlands and Islands reporting the least (10 each). If the University of Dundee is excluded, the average number of reports for Cluster 2 drops to 16, indicating a higher variance in reporting within this cluster.

In Cluster 3, the average scope 3 emissions per internal area are slightly higher despite the reduced average internal area compared to Clusters 1 and 2. Glasgow Caledonian University stands out within this cluster, with a gross internal area ranking fourth from the bottom at 100,808 m^2, but having the third-highest scope 3 emissions at 13,887 tCO_2e. Although Glasgow Caledonian University falls into Cluster 2 based on its creation date, its reporting format and the number of activities recorded align more with Cluster 1. If Glasgow Caledonian University is removed from Cluster 3, the average scope 3 emissions per internal area decrease to 9.5 tCO_2e/m^2. Within Cluster 3, Glasgow Caledonian University reported the highest number of activities (49), while RGU and Abertay University reported the lowest (7 each). Two conclusions can be drawn from these results: (a) the HEIs within Cluster 3 do not report enough activity data to reflect their total carbon footprint, and (b) the number of reported activities for all HEIs within Cluster 3 must be close to that of Glasgow Caledonian University. Glasgow Caledonian University's scope 3 reporting structure is meticulous, providing detailed travel emission data, unlike other HEIs in Cluster 3. Consequently, the scope 3 emissions per internal area for Glasgow Caledonian University are the highest at 137, more than double that of the second-ranked HEI which is University of Glasgow. For Glasgow Caledonian University, the average number of buildings among the ancient HEIs is 256, whereas the average number of buildings for modern HEIs is 37. It's important to note that this calculation does not include the University of the Highlands and Islands and SRUC, as they are aggregations of several smaller colleges and universities within Scotland.

Figure 5-23 depicts the relationship between the foundation year and energy consumption per square meter of the internal area. The plot indicates that energy consumption is high for ancient HEIs and lower for modern HEIs. However, there are a few exceptions to this relationship. HEIs such as Glasgow Caledonian University, RGU, and Heriot-Watt University, which are modern universities, exhibit energy consumption rates similar to ancient HEIs. This could be attributed to either (a) successful climate change initiatives implemented by ancient HEIs to reduce energy consumption or (b) certain modern HEIs having less energy-efficient buildings.

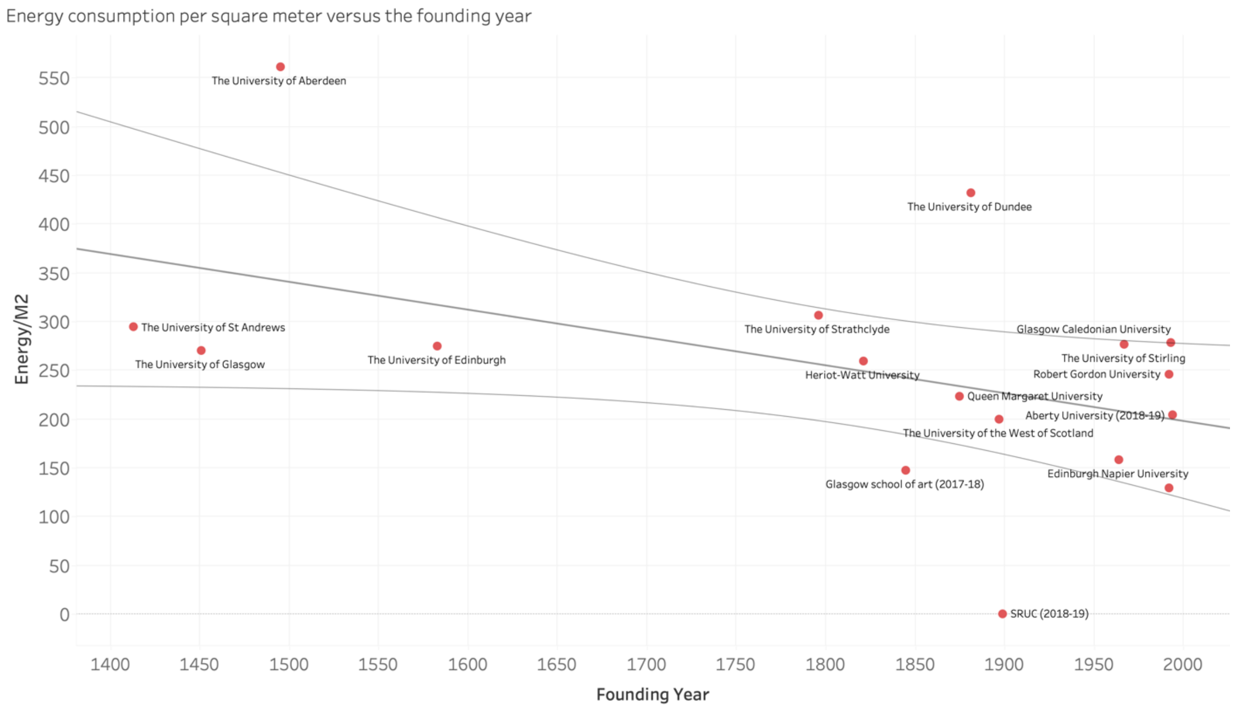

Figure 5-23: Energy consumption per square meter against the foundation year

5.4 Energy consumption per square meter versus the gross internal area

Based on the previous analysis, it is evident that energy consumption is a key driver of emissions across all scopes. As the internal area of HEIs increases, energy consumption tends to increase as well. The HEI emissions tracking data reveals that energy consumption can be divided into two distinct activities: (a) grid electricity generation and (b) grid electricity T&D. Grid electricity generation is classified as scope 2 emissions, while T&D is classified as scope 3 emissions.

Out of the 17 HEIs, 10 have reported grid electricity T&D data for the year 2019. However, even if an HEI does not report T&D emissions, a fair approximation can be derived from the grid electricity generation data. To gain insights into the efficiency of each HEI and evaluate the effectiveness of climate change mitigation strategies, understanding energy usage per square meter is crucial. This information can provide valuable insights into the relationship between gross internal area and energy consumption per square meter.

Figure 5-24 visualises the relationship between the gross internal area and energy consumption per square meter of the gross internal area.

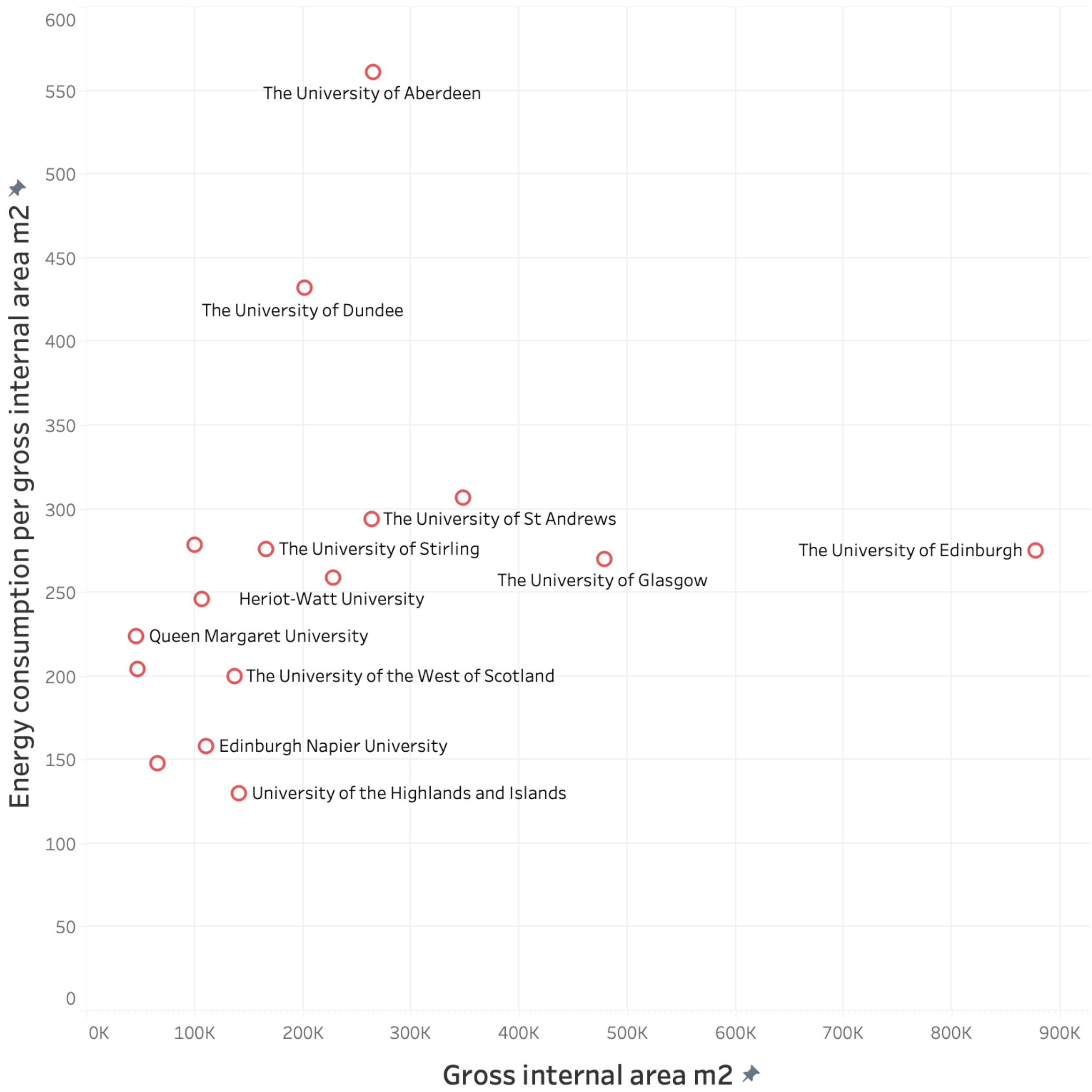

Figure 5-24: Gross internal area (m2) Vs Energy consumption per square meter

Figure 5-24 provides a scatter plot showcasing the energy consumption per internal area. The University of Aberdeen exhibited the highest energy consumption per internal area at 561 kWh/m2. University of Aberdeen is an ancient university with a sprawling campus area. However, the other four ancient universities (University of St Andrews, University of Strathclyde, University of Glasgow, and University of Edinburgh) had energy consumption per internal area around the average value of 307 kWh/m2. Despite having the largest internal area of 877,348 m2, the University of Edinburgh consumed less energy per square meter compared to the national average. This indicates that the University of Edinburgh is highly effective in addressing climate change challenges at the ground level. Perhaps other ancient universities can look to the University of Edinburgh as a benchmark for achieving their climate change reduction goals. Edinburgh Napier University, Glasgow School of Art, and the University of the Highlands and Islands had the lowest energy consumption per square meter, primarily due to their smaller internal areas. However, Glasgow Caledonian University stands as a contradiction, ranking 5th in terms of energy usage per square meter despite being 13th in terms of internal area. Similarly, RGU exhibited higher energy consumption per square meter relative to its gross internal area.

All HEIs in Scotland reported energy consumption data in kilowatt-hours (kWh). From this data, two types of indirect emissions can be derived: emissions from electricity generation (scope 2) and emissions from electricity T&D (scope 3). While the activity data remains the same for both emissions, the emission factors (EF) differ. Ideally, all HEIs in Scotland should have the same EF for T&D. However, Table 5-21 indicates that the EF for T&D varied across the years studied (2015 to 2020) among the Scottish HEIs, demonstrating inconsistencies in the emission factors used for T&D.

Table 5-20 The variation in the T&D EF across Scottish HEI

Year	**EF-1 (kg CO2e/kWh)**	**Number of HEI using EF-1**	**EF-2 (kg CO2e/kWh)**	**Number of HEI using EF-2**	**HEI that did not report T&D emissions**	**The difference in the EF. with w.r.t lower EF.**
2015	0.03816	4	0.04322	6	8	13%
2016	0.03727	13	0.03816	2	3	2.4%
2017	0.03287	12	0.03727	3	3	13.4%
2018	0.02413	13	0.03287	1	4	36.2%
2019	0.0217	11	0.02413	2	5	11.2%
2020	0.02005	12	0.0217	2	4	8.2%

During the given period, at least three HEIs did not report their grid electricity T&D emissions. This lack of reporting makes it difficult to assess the full extent of emissions from T&D activities. Additionally, two different EFs were observed for the grid electricity T&D emissions, with differences ranging from 2.4% to as high as 36.2%. In 2015, the highest variance was observed, with four HEIs using an EF of 0.03816 kg CO2e/kWh, six HEIs using an EF of 0.04322 kg CO2e/kWh, and eight HEIs not reporting T&D emissions at all. Throughout the years 2015 to 2020, HEIs employed two different EFs annually, indicating inconsistencies in the calculation of T&D emissions.

SRUC, Glasgow School of Art, and the University of the Highlands and Islands consistently belonged to the minority group within the EF grouping. The University of Edinburgh did not report grid T&D emissions for the years 2015 and 2019, while the University of Dundee started reporting grid T&D emissions in 2019. Reporting grid emissions, whether it is generation (scope 2) or T&D (scope 3), is relatively straightforward as accurate activity data can be obtained from electricity meters. However, the reasons for a small number of HEIs not reporting grid T&D emissions when the necessary data is easily accessible remain unclear.

5.5 Relationship between scope 3 emissions and field of study

Scope 3 emission per student FTE (f3) based on the subject studied

For this section, Scope 3 emissions per student FTE is represented as f3, and the Scope 1 and 2 emissions per student FTE will be represented as f1. Table 5-22 provides the average percentage breakdown of emissions per student FTE for the field of study within the f3 cluster, while Table 5-23 shows the results for the f1 cluster. The interquartile range is used to group HEIs into four groups.

In Table 5-22, the f3 cluster results are presented against the field of study. It is observed that as f3 increases, the share of student FTE increases for the field of Medicine, Dentistry & Health, while it decreases for Agriculture, Forestry & Veterinary Science, Education, and Engineering & Technology. Conversely, HEIs with a higher proportion of student FTE in the fields of Medicine, Dentistry & Health, Administration & Business Studies, and Design, Creative & Performing Arts tend to show an inverse relationship with f1. The field of Biological, Mathematical & Physical Sciences, on the other hand, exhibits a direct relationship with f1. In summary, there is no clear relationship between the f1 clusters of HEIs and the field of study.

Table 5-23 presents the average f1 and f3 for each cluster against the subject area, providing a description of the cluster beneath it. This information allows for an understanding of the relationship between emissions per student FTE and the field of study.

Table 5-21 The table shows the average breakdown of scope 3 emissions per student FTE for the field of study

	Medicine, dentistry & health	Agriculture, forestry & veterinary science	Biological, mathematical & physical sciences	Architecture & planning	Administration & business studies	Social studies	Humanities & language-based studies & archaeology	Design, creative & performing arts	Education	Engineering & technology
Cluster 1	15%	8%	14%	2%	16%	15%	9%	3%	8%	10%
Cluster 2	19%	1%	12%	5%	13%	12%	7%	15%	4%	13%
Cluster 3	18%	6%	14%	5%	13%	11%	8%	12%	3%	3%
Cluster 4	19%	1%	13%	5%	13%	12%	9%	15%	2%	2%

Quartile Range: Minimum: 0.017519271, Quartile 1: 0.077575333, Median: 0.475579809, Quartile 3: 0.6589701, Maximum: 0.972342809
Cluster 1: University of the Highlands and Islands, The University of Stirling, The University of Strathclyde, Robert Gordon University, The University of the West of Scotland
Cluster 2: Abertay University, Edinburgh Napier University, The University of Aberdeen, Queen Margaret University
Cluster 3: Heriot-Watt University, The University of Dundee, Glasgow school of art, SRUC (2018-19)
Cluster 4: The University of Edinburgh, The University of St Andrews, The University of Glasgow, Glasgow Caledonian University

Table 5-22 The table shows the average breakdown of scope 1 & 2 emissions per student FTE for the field of study

	Medicine, dentistry & health	Agriculture, forestry & veterinary science	Biological, mathematical & physical sciences	Architecture & planning	Administration & business studies	Social studies	Humanities & language-based studies & archaeology	Design, creative & performing arts	Education	Engineering & technology
Cluster 1	28.51%	0.93%	5.79%	1.54%	19.73	12.58%	0.04%	8.55%	0.08%	11.3%
Cluster 2	23.39%	1.03%	7.56%	3.7%	17.16%	17.38%	0.04%	6.17%	0.06%	13.8%
Cluster 3	10.51%	0.72%	19.07%	2.74%	13.69%	13.48%	0.1%	3.06%	0.07%	19.02%
Cluster 4	11.31%	14.96%	22.36%	1.63%	8.29%	12.66%	0.15%	3.91%	0.04%	5.79%

Quartile Range: Minimum: 0.055080589, Quartile 1: 0.493921575, Median: 1.148272444, Quartile 3: 1.467122617, Maximum: 3.549467153
Cluster 1: University of the Highlands and Islands, Queen Margaret University, Edinburgh Napier University, The University of the West of Scotland
Cluster 2: Abertay University, Glasgow Caledonian University, Robert Gordon University, The University of Stirling
Cluster 3: The University of Strathclyde, The University of Glasgow, The University of Aberdeen, Heriot-Watt University
Cluster 4: The University of St Andrews, The University of Dundee, The University of Edinburgh, SRUC (2018-19)

5.6 Discussion and conclusions

The result section has demonstrated that there are major modifications to the HEIs scope 3 emission reporting framework. The following sources, listed in descending order, have a maximum contribution to the scope 3 emissions, according to a five-year analysis of all HEIs reporting systems.:

1. Travel related emissions
    a. Staff commute
    b. Student commute
    c. Staff business travel
    d. Student international trip
    e. International student traveling to university and going back home
    f. Local domicile students going back home during vacation
2. Procurement
3. Grid T&D
4. Water S&T
5. Waste and recycling processing

It is noted that only a limited number of HEIs have demonstrated proper collection, estimation, and reporting of scope 3 emissions data. Gathering activity data is often identified as the most challenging aspect of this process. However, by utilising industry standards and information from comparable HEIs, an institution can estimate their scope 3 emissions. In the case of RGU, it has shown minimal scope 3 emissions reporting. This section aims to calculate the complete profile of RGU's scope 3 emissions by using primary and secondary data from other comparable universities. This exercise would help illustrate the extent of under-reporting that may be occurring within the HEI. By comparing RGU's scope 3 emissions with those of similar institutions, a more comprehensive understanding of RGU's emissions profile can be obtained.

5.6.1 Staff and student commute

Due to the small sample size and limited reporting of travel-related emissions, it is difficult to determine with certainty which component of travel has the greatest impact on scope 3 emissions. However, based on the available statistics, it can be inferred that staff and student commuting make a significant contribution to HEI scope 3 emissions.

Out of the sixteen Scottish HEIs, only five have reported commute emissions, despite commuting being a major contributor to scope 3 emissions. The four ancient universities (University of Edinburgh, University of Strathclyde, St Andrews University, and University of Glasgow) and one modern university (Glasgow Caledonian University) have reported commute emissions (Table 4.34 and Figure 4.35). Figure 4.13 classifies the universities into different clusters based on their scope 3 emissions. University of Strathclyde falls into cluster 1 as it reports scope 3 emissions of less than 20% of the total emissions. University of Edinburgh and St Andrews University fall into cluster 2 with scope 3 emissions ranging from 20% to 40%. University of Glasgow is in cluster 3, and Glasgow Caledonian University is in cluster 4. Ideally, HEIs with a high proportion of commute emissions should be part of clusters where the fraction of scope 3 emissions is significant. However, there are wide variations observed in the inter-cluster spread of HEIs. Figure 4.13 is based on 2019 data, while University of Edinburgh has reported commute emissions for all five years, University of Strathclyde for 2019 (only staff commute), St Andrews University for 2020, and Glasgow Caledonian University for 2016, 2017, 2019, and 2020.

Commuting to HEIs involves various modes of transportation, including cars, trains, buses, bikes, and walking. The challenge lies in accurately recording the distance traveled by each mode of transport in the commute survey. Furthermore, within each mode of transportation, there can be variations, such as buses running on different fuels, including electric or fossil fuel. This variation significantly impacts the emissions profile of different modes of transportation. Another challenge arises when individuals do not have a fixed mode of commute and may switch between different modes on different days.

Versteijlen et al. (2017) reported that for Dutch universities, student commute emissions accounted for 36% to 72% of total emissions, while staff commute emissions accounted for 5% to 10%. It should be noted that there are typically more students than staff in HEIs, so the absolute emissions or percentage emissions will be higher for students. Comparing commute emissions between two HEIs can be done using emissions per person-trip, which considers emissions per individual, distance traveled, and mode of transportation. Mathez et al. (2013) found that students generate 3.6 times fewer emissions per person-trip compared to staff. This difference is primarily due to students' preference for walking, cycling, or using public transport, while staff tend to drive to work (Sobrino and Arce, 2021). Students' choice to walk or cycle is often driven by cost considerations, where those who have driving licenses and can afford fuel may prefer to drive to campus (Shannon et al., 2006).

Similar patterns were observed in Scottish HEIs, where students preferred walking and public transport, while staff members preferred driving personal cars. According to the University of Edinburgh travel survey, 60% of students walked, followed by 20% using buses. Among staff members, 30% drove their cars, while 25% took the bus and 25% walked (University of Edinburgh, 2021). The survey also revealed that reduced journey time was the main incentive for students and staff to switch from cars to low-emission travel modes. However, reducing journey time may not always be feasible due to the built environment and campus setup. Therefore, HEIs need to explore other approaches to encourage the use of public transport. The availability and usage of trains, trams, and buses also depend on local city planning. For example, trains are widely used at the University of Edinburgh, while they may be rarely used at the University of Leon, Spain (David Pérez-Neira et al., 2020). HEIs can play an essential role by providing feedback to local authorities on city planning.

Additionally, raising awareness among the HEI community adds another layer of complexity to the challenges faced. Delmas et al. (2013) concluded that effective communication can greatly facilitate the promotion of sustainable mobility and encourage individuals to use low-emission travel modes.

Measuring staff and student commute emissions is indeed a complex task, as highlighted by Townsend and Barrett (2015). The main challenge lies in collecting reliable and comprehensive activity data for a large number of individuals. Given the high headcount, it is impractical to gather complete data on staff and student commute activity. Therefore, sampling methods are typically used to examine a subset of the population and infer the characteristics of the entire population.

As there is no person-trip data available for HEIs, it is not possible to directly compare emissions/person-trip between two HEIs. Instead, the commute emissions per student FTE are used to compare University of Edinburgh, St Andrews University, and Glasgow Caledonian University. University of Edinburgh has shown continuous improvement in KgCO2e/FTE students, reducing the value from 161 KgCO2e/FTES in 2015 to 90 KgCO2e/FTES in 2020. On the other hand, Glasgow Caledonian University has a wider range of values, ranging from 620 KgCO2e/student FTE to 215 KgCO2e/student FTE. These significant differences in KgCO2e/FTES between the two HEIs highlight the complexity and variability in measuring commute emissions.

Versteijlen et al. (2017) conducted a study indicating that student commute emissions in the USA and UK typically range from 300 to 600 KgCO2e/student. The emissions from Glasgow Caledonian University fall within this range, while University of Edinburgh exhibits much lower values. Overall, measuring commute emissions is a challenging task, and variations in data collection and reporting can lead to significant differences in the emissions values observed among HEIs..

Table 5-23 FTE student normalised student emissions

HEI	Commute Kg CO2e/Student FTE					
	2015	**2016**	**2017**	**2018**	**2019**	**2020**
University of Edinburgh	161	137	130	127	121	90
St Andrews University	NA	NA	NA	NA	NA	49
Glasgow Caledonian University	NA	620	586	NA	350	215

NA- Data not available

Indeed, the size and area of an HEI can have a significant impact on commute emissions. In the case of University of Edinburgh, with a gross internal area of 934,000 square meters, the larger campus area may result in longer commuting distances for students and staff compared to a smaller HEI like Glasgow Caledonian University, which has a gross internal area of 89,500 square meters. The substantial difference in the internal area between these two universities contributes to the notable variation in commuting emissions. Additionally, the location and size of the city where the HEI is situated can also influence commute emissions. St Andrews, for example, is a small city with an area of 5 km2. The compact size of the city likely leads to shorter commuting distances for students and staff, further impacting the lower commute emissions per student FTE in St Andrews University compared to larger cities like Edinburgh and Glasgow. This suggests that in smaller cities where HEIs are located, the commute emissions per student FTE in St Andrews can serve as a proxy to estimate the commute emissions of other HEIs in similar settings, allowing for peer comparisons.

Considering these factors, it is important to take into account the size and location of the HEI and the associated city when evaluating and comparing commute emissions. This understanding can help inform strategies and initiatives to reduce commute emissions and promote sustainable travel options within the HEI community.

Davison et al. (2015) also concluded that Scotland exhibits considerable variation in commute distance, with a significant number of students relying on public transportation. The study further demonstrated that students living at their permanent address, particularly those who are local residents, contribute to higher commute emissions. To validate the findings regarding high emissions from local domicile students, data from the University of Edinburgh and GCU were analyzed. The proportion of local domicile students at the University of Edinburgh was 8%, whereas it reached 25% at GCU (HESA, 2022). These results align with the conclusions drawn by Davison et al. (2015) since the University of Edinburgh exhibits lower emissions per student compared to GCU. Additionally, the emissions resulting from student commutes are influenced by the home location of non-domicile students. If a significant number of non-domicile students are international, their long-haul flights to and from their home countries must be accounted for as part of scope 3 emissions (refer to Figure 5-22). In fact, the long-haul flights of international students can contribute as much as 50% to scope 3 emissions. Although these students may reduce emissions from local commuting, the emissions associated with long-haul flights are significant. It is important to note that the available data is currently insufficient to conduct a more detailed analysis of emissions related to domicile, non-domicile, and international students.

The University of Edinburgh staff emissions for 2020 were 504 KgCO2/FTE (staff), which is 5.5 times the students' commute emissions per capita. Similarly, GCU staff emissions were 448 KgCO2/FTE (staff) (2 times), and St Andrews University was 477 KgCO2/FTE (staff) (9.7 times). Mathez et al. (2013) conducted a similar study where the staff emitted 3.6 times more emissions than the student commute. Understandably, most works of literature discussed above are skewed towards calculating students' commute emissions because they have a higher proportion of emissions. Inadept study on staff commute behaviour is lacking.

5.6.2 Travel survey data quality

The discussion above highlights the complexity associated with estimating staff and student commute emissions. HEIs should focus on selecting the appropriate survey questions and conducting surveys more frequently to improve the accuracy of data. Conducting surveys more regularly would help HEIs enhance data quality at a faster pace. Currently, most Scottish HEIs conduct travel surveys once every two years or annually, which can lead to slow incremental progress. By conducting a travel survey every semester, HEIs can expedite the resolution of data quality issues.

There are several campus carbon calculators available for free use, such as the Clean Air-Cool Planet Carbon Calculator, Campus Carbon Calculator, and Carbon Footprint Assessment Tool for Universities. Among these, the Campus Carbon Calculator is the most popular choice among HEIs (Appleyard et al., 2018). As demonstrated in the above analysis, various factors within student commuting, such as gender, age, part-time/full-time status, and domicile/non-domicile status, contribute to different commuting behaviors. Therefore, a comprehensive travel survey should aim to capture these factors.

For HEIs starting a travel survey for the first time, it is advisable to begin with a simple set of questions, including demographic details, origin postcode, destination postcode (for multiple campuses), and mode of transport. These three broad questions are sufficient to gain an initial understanding of commute emissions. As understanding and comprehension grow, more demographic information can be incorporated, and greater emphasis can be placed on individual transit splits and the number of travel days. DEFRA conversion factors are widely used within the UK and internationally to calculate emissions derived from travel surveys.

Where not enough data is available for meaningful analysis, the commute emissions can be calculated using the data from other similar HEI. It is impossible to get an exactly similar HEI. The aim must be to derive the data with the best possible comparable HEI. The similarity can be derived by comparing the demography of the students, foundation year, subject area (STEM, Business, research, teaching), the location from the city centre, and the city size. The first focus must be on the proportion of domicile and non-domicile students.

6. RGU Scope 3 emission calculation

6.1 RGU peer analysis

RGU (Robert Gordon University) is a public university that originated as an educational institute in the 18th century. It attained university status in 1992 and is categorized as a modern university. The university is situated on a single campus located in Garthdee, approximately 3 miles away from the city centre (refer to Figure 6-1). The surrounding area near the Garthdee campus mainly consists of residential neighborhoods, while shopping malls, restaurants, bars, and other social activity venues are primarily concentrated in the city centre, which is in close proximity.

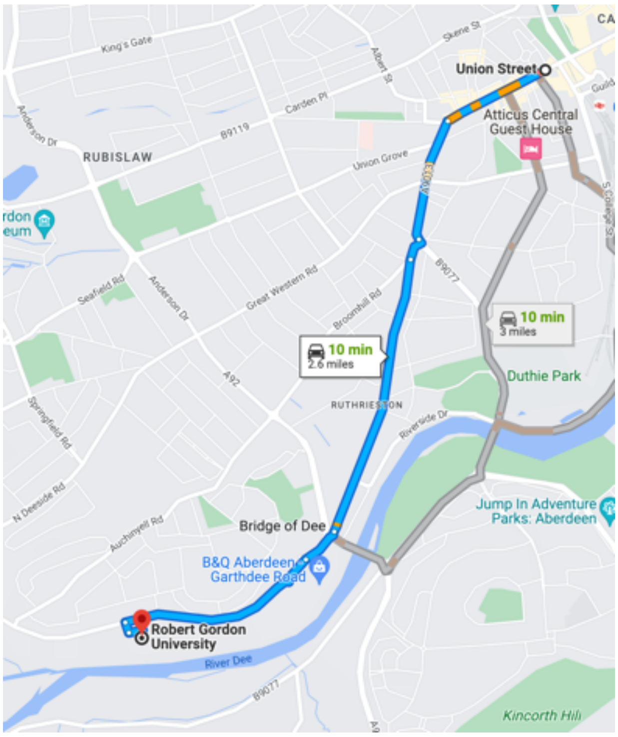

Figure 6-1: Geographic location of RGU

As of 2020, RGU had a total of 28 buildings covering an area of 560,000 square meters. The gross interior area of these buildings amounted to 104,787 square meters, and the energy consumption recorded was 26,147 GWh. The university provided 1,112 parking spaces and 288 cycling spaces for transportation purposes. In terms of financials, RGU reported a total income of GBP 92.8 million. Out of this amount, GBP 78 million was contributed by teaching activities, indicating a strong emphasis on teaching. Research activities contributed GBP 5 million to the total income. On the expenditure side, the university's total expenditure amounted to GBP 101 million. For the specific figures regarding full-time equivalent (FTE) students and staff, please refer to Table 6-1

Table 6-1: RGU-Number of FTE staff, student, income, expenditure, and area from 2015 to 2020

	FTE student	FTE staff	Expenditure GBP	Income GBP	Floor area m2
2016	8340	1230	105,800,000	97,413,000	117,894
2017	8285	1125	101,595,000	93,839,000	107,218
2018	8465	1160	105,989,000	93,383,000	107,218
2019	8195	1190	100,078,000	91,943,000	107,218
2020	8270	1156	101,460,000	92,853,000	104,787

Over the span of five years, RGU experienced a 1% decline in the number of full-time equivalent (FTE) students. Similarly, FTE staff, income, and expenditure all decreased by 5% during the same period. In terms of emissions, scope 3 emissions witnessed a notable reduction of 44%, while total emissions decreased by 40%.

However, it is important to note that the emissions figures provided by RGU are highly questionable due to the exclusion of travel and commute emissions, which are significant contributors to both scope 3 and total emissions. Considering that 60% of the students are enrolled in programs related to allied medicine, business, and social sciences, it becomes crucial to recalculate RGU's scope 3 emissions in this chapter. The assumption is made that no primary data is available, and the recalculations will be based on the findings presented in the previous chapters.

This study utilises inductive reasoning to recalculate RGU's emissions, based on the data collected and analysed in the previous chapters. By applying best practices, incorporating research outcomes from past literature, and adapting data from a similar setup, new knowledge is developed regarding RGU's scope 3 emissions.

The first step involves identifying an HEI that is identical to RGU and has reported comprehensive scope 3 data. The foundation year analysis in Table 6-2 reveals both similarities and differences in scope 3 reporting. Three HEIs—GCU, UHI, and AU—are identified as being similar to RGU, as they were granted university status after 1990 and exhibited a comparable energy consumption rate. However, only GCU has complete reporting of scope 3 emissions. Other HEIs with comprehensive scope 3 reporting include the University of Edinburgh, St Andrews University, and the University of Glasgow. However, these institutions are ancient universities and not directly comparable to RGU.

Table 6-2: The relative comparison between RGU and GCU

	RGU	**GCU**
Established Year	1992	1993
Number of students FTE (2020)	8270	11,765
Number of staff FTE (2020)	1,165	1400
Total income (2020)	92,583,000	125,305,000
Total research income (2020)	4,922,000	9,821,000
Total teaching income (2020)	78,011,000	116,827,000
Total expenditure (2020)	101,460,000	127,560,000
Gross internal area (m2)	104,787	100,808
Number of buildings	28	23

RGU and GCU demonstrate striking similarities in terms of the number of buildings, gross internal areas, and foundation years. However, there are notable differences in the income-to-expense ratio and research income between the two universities. For RGU, the income-to-expense ratio stands at 91%, whereas GCU boasts a higher ratio of 98%. In terms of research income, RGU's research income constitutes 5% of the total income, whereas GCU's research income comprises 8% of the total income.

Furthermore, GCU has a student population that is 42% larger than that of RGU, while the FTE staff at GCU is 20% higher compared to RGU. To gain further insights and a subject-wise comparison between RGU and GCU, please refer to Table 6-3

Table 6-3: 2020 breakdown of the number of students studying different subjects in RGU and GCU

Subject	GCU	% of total students at GCU	RGU	% of total students RGU
01 Medicine and dentistry	125	0.66%	0	0.00%
02 Subjects allied with medicine	6,590	34.63%	4,090	28.72%
03 Biological and sports sciences	150	0.79%	210	1.47%
04 Psychology	530	2.79%	80	0.56%
05 Veterinary sciences	0	0.00%	0	0.00%
06 Agriculture, food, and related studies	65	0.34%	0	0.00%
07 Physical sciences	175	0.92%	170	1.19%
09 Mathematical sciences	0	0.00%	0	0.00%
10 Engineering and technology	1,790	9.41%	880	6.18%
11 Computing	1,365	7.17%	965	6.78%
13 Architecture, building, and planning	1,280	6.73%	670	4.71%
26 Geography, earth and environmental studies (natural sciences)	0	0.00%	0	0.00%
15 Social sciences	1,310	6.88%	1,035	7.27%
16 Law	345	1.81%	790	5.55%
17 Business and management	4,360	22.91%	2,945	20.68%
19 Language and area studies	60	0.32%	0	0.00%
20 Historical, philosophical, and religious studies	0	0.00%	0	0.00%
22 Education and teaching	0	0.00%	255	1.79%
23 Combined and general studies	40	0.21%	680	4.78%
24 Media, journalism, and communications	445	2.34%	740	5.20%
25 Design and creative and performing arts	390	2.05%	720	5.06%
26 Geography, earth and environmental studies (social sciences)	0	0.00%	0	0.00%
Total	19,030	100%	14,240	100%

The yellow highlight represents the highest contribution

The breakdown comparison of RGU and GCU regarding the number of students studying different subjects indicates a similar pattern. The top four subjects, namely subjects allied to medicine, Business, management, engineering, and computing, contribute significantly to both universities. These four subjects collectively account for 74% of GCU's student population and 62% of RGU's student population. Furthermore, from Figure 6-1, it is evident that RGU is situated 3 miles away from Aberdeen city centre, whereas GCU is located at a distance of 0.6 miles (Figure 6-2). This difference in university location is likely to impact the profile of student commute emissions between the two institutions. The proximity of GCU to the city centre may result in different commuting patterns and potentially different emissions profiles compared to RGU..

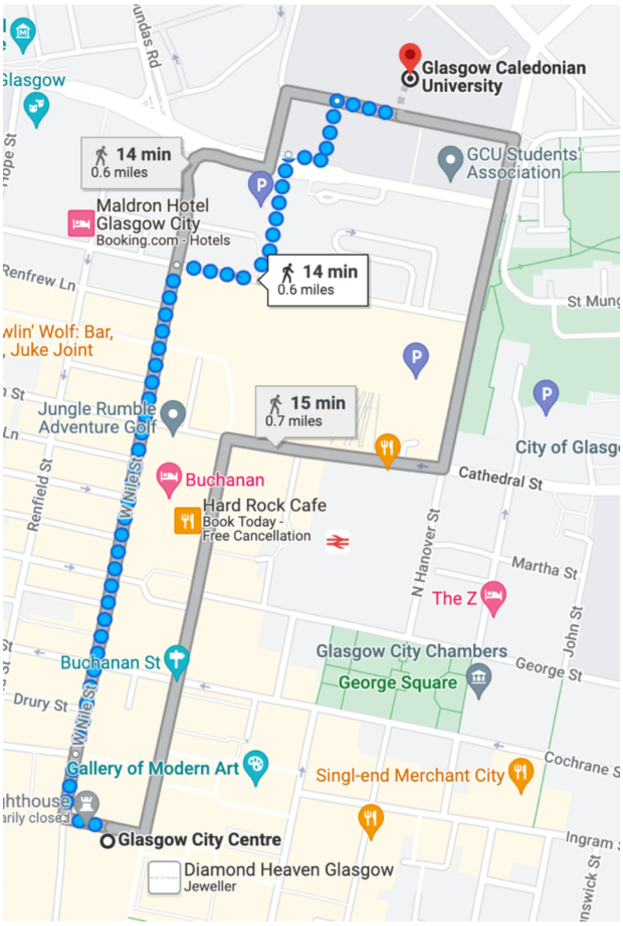

Figure 6-2: GCU distance from Glasgow city centre

In 2020, GCU had 24% of its students residing in Glasgow city. In the absence of primary data, it is assumed that these students would be considered domiciled in Glasgow and exhibit domicile-related behavior, such as commuting from home. It is also likely that they would have a higher propensity to use cars for transportation, provided they possess a driver's license and have the financial means to do so. Similarly, RGU also has a comparable domicile profile, with 25% of its students having their permanent address in Aberdeen city. This indicates that a significant portion of RGU students can be considered domiciled in Aberdeen, and their commuting behavior may align with that of Glasgow students.

For a visual representation and further comparison, please refer to Figure 6-3.

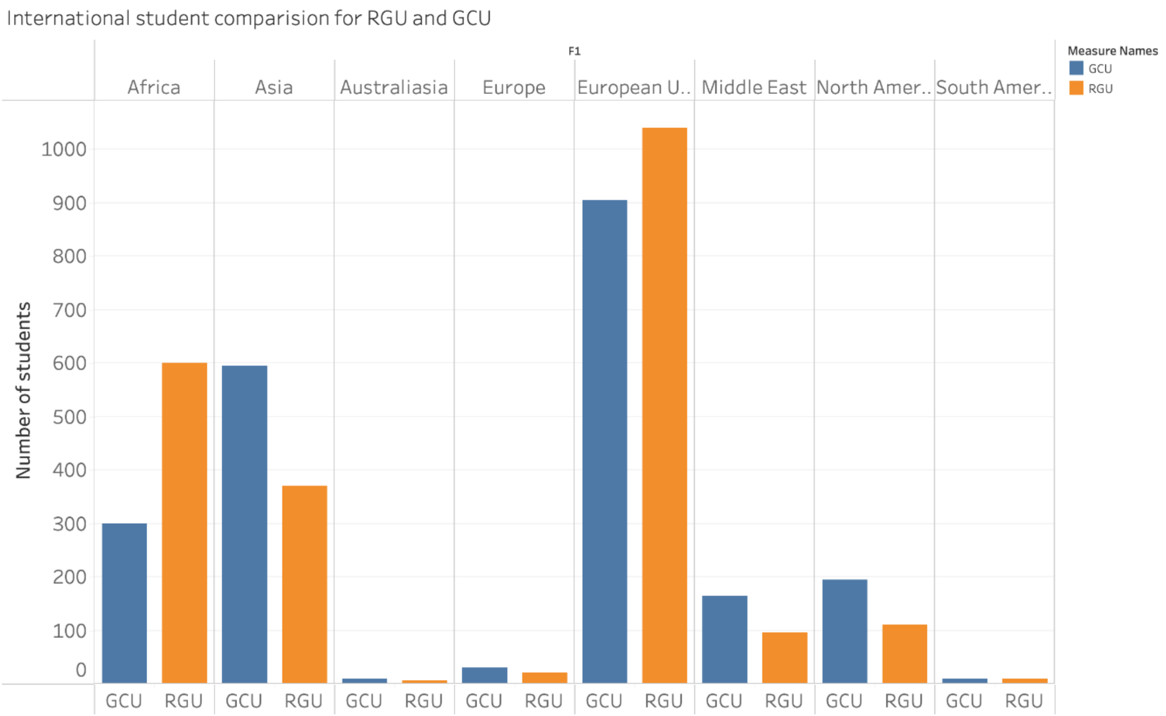

Figure 6-3: International student comparison between RGU and GCU

(Source: HESA)

Despite some differences, the profile of GCU is considered the most suitable for deriving the scope 3 emissions profile of RGU. While the results may not be entirely accurate, this approach can still provide RGU with valuable insights into its emission profile.

6.2 RGU travel emissions-derivation

6.2.1 RGU student commute emissions

The analysis till now indicates that RGU has not calculated any travel-related emissions highlights the need to estimate RGU's travel emissions using the analysis outcomes from section 6.1, with GCU data as a reference. Table 6-4 provides normalised commute emissions data in relation to FTE students, which can be utilised to estimate RGU's commute emissions. By leveraging GCU's data as the closest comparable institution to RGU, an estimation of RGU's travel-related emissions can be derived.

Table 6-4 presents the RGU commuting emissions from 2016 to 2021. It should be noted that for 2018, GCU aggregated the staff and student commute emissions. The value presented in Table 6-4 for 2018 is an average derived from the data of 2017 and 2019. RGU has reported scope 3 emissions ranging from 573 tCO2e to 282 tCO2e from 2016 to 2021, excluding high emission sources such as travel. Remarkably, between 2016 and 2019, the reported commute emissions alone were eight to nine times higher than the reported total scope 3 emissions. This result underscores the significance of calculating and reporting commute-related emissions for higher education institutions (HEIs). It is evident that including commute-related emissions is vital for a comprehensive understanding of an HEI's emissions profile.HEI.

Table 6-4: RGU student commute emission estimation

Year	GCU Kg CO2e/Student FTE	RGU- FTE students	RGU commute emissions (tCo2e)
2016	620	8340	5170
2017	586	8285	4855
2018	468 (derived)	8465	3961 (derived)
2019	350	8195	2868
2020	215	8270	1778
2021	2.2	9130	20

(2021- GCU FTE student- 15358; 34.4 tCO2e = 34400 KgCO2e; Budget: 124,000,000)

(RGU 2021- budget 107,065,000; scope 3: 288 tco2e; total emissions 6090) (RGU 2020- budget 10,52,94,000; scope 3: 282)

The academic year in the UK typically begins in September. In October 2019, COVID-19 cases were first reported in China, and a nationwide lockdown in the UK commenced in March 2020. As a result, Scottish HEIs operated for approximately five to seven months during that period. This duration likely had a significant impact on various scope 3 emissions, including travel, grid transmission and distribution (T&D), and water supply and treatment (S&T). The subsequent year (2021) saw HEIs completely shut down for in-person operations due to the pandemic. The impact of the lockdown is evident in the 2021 emissions reported by GCU and the derived emissions for RGU. It is difficult to determine, based on the available data, whether COVID-19 had a significant impact on scope 3 emissions in 2020. During the previous semester, project work likely did not require commuting to school, and students had already completed a significant portion of their commute for the year (2020).

In 2021, GCU reported a drastic 99% reduction in scope 3 emissions per FTE student, demonstrating the positive impact of the lockdown on HEI scope 3 emissions. This decrease in commute emissions occurred despite the university's budget being similar to the previous year. Similarly, RGU's commute emissions may have also fallen by 99%, as shown in Table 6-4. Even in the case of RGU, the budget was nearly the same as the previous year.

Table 6-5 presents the estimated FTE staff commute emissions for RGU, derived from GCU data. These estimations provide insights into the impact of the lockdown on staff commute emissions for RGU..

6.2.2 RGU staff commute emissions

Table 6-5: RGU staff commute emission estimation

Year	GCU Kg CO2e/staff FTE	RGU- FTE staff	RGU staff commute emissions (tCO2e)	RGU staff commute as % of student commute
2016	586	1220	715	14%
2017	582	1145	666	14%
2018	681 (derived)	1182	805	20%
2019	780	1207	941	33%
2020	449	1207	542	30%
2021	24.5	1217	0.03	666%

In 2016, the staff commute emissions were 14% of student commute emissions, up to 30% in 2020 and 666% in 2021. The lockdown impact is also visible in the staff commute emissions. The normalised staff commute was reduced by 42% from 2019 to 2020 when the partial academic year was under lockdown. In 2021, the normalised staff commute emissions were reduced by 94%, and absolute staff commute emissions were reduced by 99%. The data also shows that in 2021, far fewer staff visited campus than students.

6.2.3 International student flight emissions

Figure 6-3 (above) highlights the importance of including international students' flights to and from their home countries in scope 3 emissions to account for the complete carbon footprint. Building upon the methodology discussed in sections 6.2.1 and 6.2.2, RGU's international student flight emissions can be estimated using GCU data and domicile statistics. The detailed derivation is outlined in the following section.

To gather data on RGU's international student profile, information was collected from the HESA (Higher Education Statistics Agency) database. The international students were categorised based on their continents, including Asia, Africa, EU, North America, South America, Middle East, and

Australasia. Further subdivision was done to identify individual countries within each continent. The global student breakdown data for RGU was collected for the period from 2016 to 2021. Since the number of students from Australasia was relatively small, their data was disregarded for the analysis.

For the estimation of flight emissions, the origin city was considered as Aberdeen, and the capital city of the student's home country was regarded as the destination city. For instance, if a student is from Nigeria (Africa), Aberdeen is considered the origin city, and the destination city is Lagos. The flight distance is then calculated between Aberdeen and the destination city. For EU students, emissions were calculated using the 'domestic average passenger' flight emission factor (EF) from Table 6-7. On the other hand, for countries outside of the EU, the long-haul average passenger flight EF from Table 6-7 was utilised. These EFs were used to calculate emissions for each flight.

The emissions derived from the above calculation methodology are presented in Table 6-6. This table provides insights into the estimated flight emissions of RGU's international students from 2016 to 2021, considering their respective continents and countries of origin.

Table 6-6: Number of students from different regions and their per capita emissions

Region	Number of students (2020)	Emissions per student tCO2e (2020)
Asia	380	1.5
Africa	580	1.08
EU	1050	0.2
Middle East	95	0.99
North America	105	1.15
South America	10	1.65

RGU has witnessed the highest number of students from the EU, followed by Africa and Asia, with South America contributing the least. Surprisingly, despite having the lowest number of students, South America has the highest per capita emissions at 1.65 tCO2e per student, followed by North America. In contrast, the EU, with the highest student count, demonstrates the least per capita emissions at 0.2 tCO2e per student. From 2016 to 2021, African students accounted for the highest proportion of international student emissions, contributing 49%, followed by Asia at 31% and the EU at 10%. The total flight emissions from international students ranged from 2,905 tCO2e in 2019 to

4,496 tCO2e in 2021. Notably, flight emissions were on a downward trend from 2016 to 2019, but started to increase after the COVID-induced lockdown.

Considering the COVID-induced lockdown, which began in March 2020, it can be assumed that all international students enrolling for the 2019-2020 academic year may have traveled internationally from their home countries to RGU and then returned home during the lockdown period. In 2020, no international student took an international flight due to the year-long lockdown. Therefore, the flight emissions calculated for 2021 in this study (Table 6-6) did not actually occur. It can be inferred that RGU saved 4,496 tCO2e in flight emissions for 2021 as a result of the lockdown measures (Davison et al., 2015).

In Section 6.2.1, it was discussed that non-domicile students tend to live close to the campus and are more likely to use public transport, while domicile students are more inclined to use a car if they have the means and a driving license (Davison et al., 2015). However, the above calculations contradict this study. The total student commute emissions for RGU in 2020 were 2,868 tCO2e, whereas the emissions from international flights were 2,905 tCO2e. This implies that student commute emissions encompass both domicile and non-domicile students, while international students' emissions comprise local commutes and international flights back home. Therefore, international students emit a significantly higher amount of CO2e compared to domicile students. Furthermore, if international students choose to drive to campus, their emissions per person would be even higher. The total commute emissions for RGU, including student and staff commutes and international student trips, amounted to 5,865 tCO2e. The theoretical emission figure for 2021 was 4,516 tCO2e, which was avoided due to the lockdown measures.

Table 6-7: The RGU commute emissions (tCO2e) from international students' trips home and back.

Continent	**2016 emissions**	**% Emission 2016**	**2017 emission**	**% Emissions 2017**	**2018**	**% Emission 2018**	**2019**	**% Emission 2019**	**2020**	**% Emission 2020**	**2021**	**% Emission 2021**
South America	81.4	2.22%	49.4	1.52%	21.0	0.66%	19.3	0.66%	33.3	0.99%	38.1	0.85%
North America	191.1	5.20%	228.9	7.05%	237.4	7.47%	246.1	8.47%	242.3	7.22%	224.8	5.00%
Middle East	245.6	6.69%	246.8	7.60%	254.1	7.99%	191.2	6.58%	188.7	5.62%	177.4	3.95%
Africa	1452.4	39.53%	1205.9	37.12%	1105.2	34.76%	1024.9	35.28%	1292.7	38.51%	2204.3	49.03%
Asia	1136.7	30.94%	975.0	30.02%	1028.2	32.33%	941.9	32.42%	1132.4	33.74%	1390.0	30.91%
European Union	566.7	15.42%	542.2	16.69%	534.0	16.79%	481.6	16.58%	467.0	13.91%	461.4	10.26%
Total	3673.8	100.00%	3248.3	100.00%	3179.8	100.00%	2905.0	100.00%	3356.4	100.00%	4496.1	100.00%

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6.2.4 Business travel emissions

Apart from RGU, University of West of Scotland, University of Aberdeen, Abartey University, and Stirling University, all other HEIs have disclosed their business travel emissions in the cluster 1 of figure 5-1. According to UNWTO (2017), business travel accounted for 13% of all flight travel as of 2016. The majority of HEI business trips are for meetings, conferences, workshops, and student exchanges, as highlighted by Randles and Mander (2009). Academics often perceive travel as necessary for career progression, particularly early-career researchers who may have a greater urge to travel due to perceived expectations.

Le Quéré et al. (2015) concluded that many travelers fly to establish connections, and a significant number of respondents believed that travel is expected by their organisations. Wynes et al. (2019) explored the hypothesis of whether travel is necessary for career progression in academia. The study found no statistical relationship between air travel and academic productivity indicators like the h-index. However, when considering seniority, a relationship between emissions and salary persisted. The authors suggested that researchers studying climate change likely have a substantial travel-related carbon footprint.

In summary, there is an opportunity to reduce emissions associated with business travel, which can sometimes be significant. However, there are contrasting conclusions regarding the importance of travel emissions. Sugimoto et al. (2017) argue that scientists tend to have higher levels of innovation when they have the freedom to travel, collaborate, and engage in joint research. Despite the differing conclusions, it is evident from the results that HEI business travel constitutes a significant portion of scope 3 emissions. Moreover, it was observed that only a limited number of HEIs reported travel emissions, and the reporting appeared to lack granularity in terms of travel data.

Estimating trip emissions, similar to calculating commuting emissions, is a challenging task due to the large number of academic trips that occur each year. Gathering and organising trip information to calculate emissions can be difficult and time-consuming. One crucial aspect is aligning the activity data (e.g., flight details) with the emission factors used for calculations. It is important to ensure that the activity data matches the granularity of the EF values for accurate emission estimation. For instance, if an EF is available for a flight with a seating capacity of 100, the activity data should be normalised based on a seating capacity of 100. However, due to variations in flight sizes and distances traveled, achieving an exact match between activity data and EF may not always be feasible. In such cases, a common practice is to retain the EF as provided and match the activity data to the nearest available EF.

DEFRA (Department for Environment, Food and Rural Affairs) releases annual EF values for various modes of transport, including air travel (as shown in table 6-8). Within air travel, EF estimations are provided for domestic flights, short-haul flights, long-haul flights, and international flights. Domestic flights are those with both the origin and destination within the UK, while short-haul flights have origin and destination locations within the European Union. Long-haul flights are those flying from the UK to destinations outside of Europe. International flights encompass all flights with non-UK destinations. Furthermore, within international flights, different classes (economy, business, first class) are accounted for, while average passenger EF is used when the exact seating class is unknown. Conferences, research project meetings, and overseas teaching assignments are the primary reasons for academic business trips. These activities contribute to the need for business travel within the academic community.

Table 6-8: DEFRA 2020 emission factor for business air travel (Radiative forcing (RF) is a measure of the additional environmental impact of aviation)

Flights	RF-2016	No-RF-2016	RF-2017	No-RF-2017	RF-2018	No-RF-2018	RF-2019	No-RF-2019	RF-2020	No-RF-2020
Domestic-Average passenger	0.27867	0.14735	0.26744	0.14141	0.29832	0.15777	0.25493	0.13483	0.2443	0.1292
Short-haul-Average passenger	0.16844	0.08905	0.16103	0.08513	0.16236	0.08584	0.15832	0.0837	0.15553	0.08223
Short-haul-Economy class	0.16508	0.08728	0.15845	0.08378	0.1597	0.08443	0.15573	0.08233	0.15298	0.08088
Short-haul-Business class	0.24761	0.13091	0.23767	0.12565	0.23955	0.12665	0.2336	0.1235	0.22947	0.12132
Long-haul-Average passenger	0.19162	0.10131	0.19745	0.10439	0.21256	0.11237	0.19562	0.10342	0.19085	0.1009
Long-haul-Economy class	0.14678	0.07761	0.15119	0.07993	0.16279	0.08607	0.14981	0.0792	0.14615	0.07727
Long-haul-Premium economy class	0.23484	0.12415	0.24189	0.12789	0.26046	0.1377	0.2397	0.12673	0.23385	0.12363
Long-haul-Business class	0.42565	0.22503	0.43843	0.23179	0.47208	0.24958	0.43446	0.22969	0.42385	0.22408
Long-haul-First class	0.58711	0.31039	0.60473	0.31971	0.65115	0.34425	0.59925	0.31681	0.58462	0.30908
International-Average passenger	0.17901	0.09464	0.18026	0.0953	0.18277	0.09663	0.18078	0.09558	0.18181	0.09612
International-Economy class	0.13712	0.072495	0.13801	0.072965	0.139964	0.0739947	0.138445	0.0731953	0.139245	0.0736152
International-Premium economy class	0.21939	0.11599	0.22084	0.11675	0.22395	0.1184	0.22151	0.11711	0.22278	0.11778
International-Business class	0.39764	0.21022	0.40025	0.2116	0.4059	0.21459	0.40149	0.21226	0.40379	0.21348
International-First class	0.54846	0.28996	0.55209	0.29188	0.55987	0.29599	0.55376	0.29276	0.55695	0.29445

Source: (DEFRA, 2016-2020)

Prior to 2020, the Boeing 737's flying range served as the basis for distinguishing between short-haul and long-haul flights. Flights covering less than 3700 km were classified as short-haul, while those covering more than 3700 km were categorized as long-haul. The air travel emission factors (EF) also include a portion of indirect emissions related to the production and distribution of fuel. DEFRA has estimated 28 different EF based on these parameters for various flying conditions, and these EF values are widely used in the UK and internationally (Wynes et al., 2019). In the EF estimation, 53 different aircraft models were considered. Additional parameters utilised in the EF calculation include the average number of seats, average load factor, proportion of passenger-kilometers, and average flight length.

These considerations help provide a more accurate estimation of emissions associated with different types of flights based on their distance and other relevant factors. The use of specific EF values ensures that emissions calculations align with the characteristics of the flights being assessed, enabling a more precise estimation of the carbon footprint attributed to air travel.

To calculate emissions accurately, flight travel activity data must be mapped with the 28 EFs provided by DEFRA. DEFRA encourages organisations to use Radiative Forcing (RF) EFs as they account for additional flight-related emissions. However, DEFRA cautions that using RF EFs can introduce significant uncertainty. RF EFs are approximately double the magnitude of normal EFs. The choice of EF (RF or non-RF) can significantly impact the emissions results. It is crucial for organisations to maintain consistency in their use of EFs or EFs with RFs to ensure comparability of results. If different EFs are used, the emissions results become incomparable. All Scottish HEIs have applied RF EFs to estimate their business air travel emissions, ensuring comparability of results.

As there is no specific travel data available, the amount of business travel by RGU can be estimated by comparing it to GCU. The per capita emissions of GCU (FTE staff) can be calculated and multiplied by RGU's FTE staff count to estimate RGU's business air travel emissions. The results for RGU's emissions for the five years are shown in Table 6-9.

Table 6-9: RGUs business air travel estimation

	GCU business travel emissions (tCO2e)	GCU FTE staff	GCU per capita emissions (tCO2e/FTE staff)	RGU FTE staff	RGU business travel emissions (tCO2e)
2015	2477	1445	1.71	1220	2086
2016	1934	1450	1.33	1145	1522
2017	1414	1407	1	1182	1182
2018	1285	1385	0.92	1207	1110
2019	1555	1364	1.14	1207	1375
2020	815	1396	0.58	1217	706
2021	23.3	1404	0.02	1219	24

According to table 6-9, RGU's business travel emissions in 2015 were the highest at 2,086 tCO2e. However, over the subsequent years (2016, 2017, 2018), these emissions gradually decreased. In 2019, there was a 24% increase in business travel compared to the previous year. The lower emissions figure in 2020 reflects the impact of travel restrictions imposed due to the COVID-19 pandemic. It is important to note that air travel restrictions began earlier than the full lockdown, which contributed to the reduced emissions. Furthermore, in 2021, when the lockdown was in full effect, air transport was hardly utilised, resulting in minimal business travel emissions.

These calculations highlight the significant underreporting of RGU's scope 3 emissions. On a positive note, they also demonstrate the impact of the lockdown on scope 3 emissions. While RGU's emissions pattern is expected to be similar to GCU's due to the derivation from GCU statistics, it is important to acknowledge that these values are derived using the best available data.

6.2.5 Summary – travel-related scope 3 emissions

It is evident that RGU did not report travel-related emissions for several years, necessitating the benchmarking of RGU against GCU to derive travel-related scope 3 emissions. The calculation process involved estimating RGU's staff and student commute emissions, business travel emissions, and international student travel emissions. The results reveal that the emissions attributed to travel are significantly higher, ranging from twenty to twenty-five times greater than the reported scope 3 emissions. Table 6-10 provides a comprehensive overview of all the travel-related emissions calculated for RGU based on this derivation.

Table 6-10: RGU travel-related emissions

Year	Staff commute emissions (tCO_2e)	Student commute emissions	Business travel emissions	International student emissions	Total travel-related emissions tCO_2e
2015	NA	NA	2086	NA	NA
2016	715	5170	1522	3674	11,081
2017	666	4855	1182	3248	9,951
2018	805	3961 (derived)	1110	3180	9056
2019	941	2868	1375	2905	8089
2020	542	1778	706	3356	6382
2021	0.03	20	24	4496 (0)	88

The analysis conducted demonstrates that the two main contributors to travel-related emissions at RGU are student commutes to campus and overseas student trips. Student commute emissions decreased over time, while emissions from foreign travel remained relatively unchanged from 2015 to 2021. The emissions from international student trips were calculated for partial and complete lockdown years, with 2021 reflecting zero emissions due to the complete lockdown. Business travel emissions displayed high variability across the years, ranging from a high of 2,086 tCO_2e in 2016 to a low of 1,110 tCO_2e in 2018. Staff commute emissions constituted a smaller portion of travel-related emissions, ranging from 11.6% in 2019 to 6.5% in 2016.

To effectively reduce scope 3 emissions, RGU should focus on addressing the most significant contributors, which are international students and student commutes. International students generate higher per capita income for RGU compared to domestic students, making it economically challenging to reduce their numbers. However, encouraging online courses and targeting fewer international on-campus students could help reduce their air travel emissions, particularly in non-STEM fields.

Implementing online or hybrid education systems can significantly reduce commute emissions, as demonstrated by studies conducted at other institutions. This approach requires careful consideration and may encounter resistance from universities, students, and staff due to concerns about educational quality and the lack of on-campus experiences. However, the forced shift to online education during the COVID-19 lockdown presents an opportunity for HEIs to analyse and learn from the experience, gradually scaling up online or hybrid education modes to achieve significant scope 3 emission reductions.

Information and Communication Technology (ICT) is often touted as a solution to reduce commute emissions by enabling remote meetings and online communication. However, conducting a general Life Cycle Assessment (LCA) for ICT is challenging due to the wide variation in definitions and operations. An LCA study specific to education-related ICT is needed to understand the emissions associated with replacing student commutes with ICT. Currently, the assumption is made that the carbon impact of ICT is zero, but this assumption should be revisited as new studies adequately define ICT's carbon emissions.

Overall, the analysis highlights the potential for reducing scope 3 emissions through targeted measures such as online education and careful consideration of travel-related emissions.

6.3 Grid Transmission and Distribution emissions

There are three components to electricity emissions: electricity generation, electricity transmission and distribution (T&D), and consumption. Electricity consumption occurs on campus and is directly influenced by the actions of the HEIs, making it classified as scope 1 emissions. Electricity generation emissions, on the other hand, depend on the activities of the HEI but take place outside the campus, hence falling under scope 2 emissions. Grid electricity transmission and distribution emissions occur outside the campus and are beyond the control of the HEI, making them classified as scope 3 emissions.

Calculating emissions from grid T&D is a straightforward process. The activity data used is the same as the grid electricity consumption or generation data. Emission factors (EF) for grid T&D are published annually by organisations such as DEFRA. These EF values represent the average emissions associated with the transmission and distribution of electricity. To estimate grid T&D emissions, the grid electricity consumption or generation data is multiplied by the corresponding EF for grid T&D. This calculation helps determine the indirect emissions associated with the electricity consumed or generated by the HEI.

RGU has performed calculations for grid T&D emissions from 2015 to 2021, which are presented in table 6.11 below.

Table 6-11: RGU grid transmission and distribution emissions

Year	Activity data (kWh)	EF tCO2e/kWh	Emissions (tCO2e)	Emission reduction from the previous year
2015	11,994,539	0.04322	518.4	NA
2016	11,530,529	0.03727	429.7	17%
2017	10,720,103	0.03287	352.37	18%
2018	10,679,056	0.02413	257.69	37%
2019	10,644,865	0.0217	230.99	11%
2020	10,033,955	0.02005	201.2	12.6%
2021	9,937,214	0.01879	186.7	7.5%

Table 6-12: GCU grid transmission and distribution emissions

Year	Activity data (kWh)	EF tCO2e/kWh	Emissions (tCO2e)	Emission reduction from the previous year
2015	6,713,342	0.04322	290.2	NA
2016	7,043,672	0.03727	262.5	9.5%
2017	7,431,331	0.03287	244.3	6.9%
2018	6,643,335	0.02413	160.3	34.4%
2019	6,213,863	0.0217	134.8	16.2
2020	4,279,441	0.02005	85.8	36%
2021	2,830,466	0.01879	53.2	38.3%

Table 6-12 illustrates a significant decrease in RGU's energy transmission and distribution (T&D) emissions, with a reduction of 55% from 2015 to 2019. During the same period, energy consumption decreased by only 11%, while the emission factor (EF) decreased by 50%. The impact of COVID-19 is also evident, with partial impact in 2020 and a full impact in 2021. However, RGU did not show a significant step change in emissions from 2019 to 2020. The average year-on-year reduction in emissions for 2016, 2017, and 2019 was 15%, whereas the reduction in 2020 was 12.6%. In the full lockdown year of 2021, RGU reported only a 7.5% year-on-year reduction in emissions.

To assess the impact of the lockdown on other HEIs, RGU's grid T&D emissions are compared to its peer, GCU. Both RGU and GCU used the same emission factor. GCU also experienced a significant decrease in emissions, with a reduction of 36% in 2020 and a further 38.3% in 2021, resulting in emissions that are 60% lower than pre-lockdown levels in 2019. In comparison, RGU's reductions for 2020 and 2021 were only 12.6% and 7.5% respectively. It is questionable that RGU projected only a 20% decrease in emissions from the previous year to the lockdown in 2021. This suggests that either RGU's data on grid energy consumption is a vague estimation or there may be a recording error.

If the reduction ratio observed in GCU's emissions is applied to RGU, the estimated emissions for 2020 and 2021 would be 148 t CO2e and 91.8 t CO2e respectively, which is 50% of what was reported for 2021.

6.4 Procurement emissions

The analysis of procurement emissions has been lacking in Scottish HEIs, including RGU. Procurement encompasses a wide range of items and supplies used in the operation of the university, such as paper, copiers, kitchenware, campus vehicles, and construction tools. Unlike other scope 3 sources like commute and travel, which can be calculated using a bottom-up approach, procurement emissions present challenges due to the variation in activity and EF data across different items.

Previous studies conducted by L Ozawa-Meida et al. (2013) for De Montfort University and Thurston & Eckelman (2011) for Yale University utilised a top-down consumption-based input-output analysis to estimate procurement emissions. This approach groups various products together under a single consumption category, and emissions are calculated based on the amount of money spent. While this method involves some generalisation due to the grouping of products, it is the most effective way to estimate scope 3 procurement emissions.

However, performing a consumption-based input-output analysis for procurement is a complex and time-consuming process that requires substantial data. Therefore, it is beyond the scope of this research. Instead, this study broadly estimates RGU's procurement emissions using the results from L Ozawa-Meida et al. (2013) and Thurston & Eckelman (2011). L Ozawa-Meida et al. (2013) estimated procurement emissions to be 38% of total emissions and 48% of scope 3 emissions, while Thurston & Eckelman (2011) estimated it to be 55% of total emissions.

Considering the lack of benchmarking against total emissions, the procurement emissions for RGU are calculated using the estimate from Leticia Ozawa-Meida et al. (2013), which suggests they account for 48% of scope 3 emissions and 38% of total emissions.

$$x = 0.48(calculated\ scope\ 3 + x) - - - EQ\ 6.1$$

- The calculated scope 3 and the total emissions are shown in table 5.16. Table 5.16 scope 3 emissions are the sum of travel-related and grid emissions.
- X is the procurement emissions

RGU's procurement emissions are calculated using equation 5.1

- 2016: Calculated scope 3: 11,646 (Table 5.16)

$$x_{2016} = 0.48(11{,}646 + x_{2016})$$
$$x_{2016} = 5{,}590 + 0.48 * x_{2016}$$
$$x_{2016} = 10{,}750\ tCO2e$$

- 2017: Calculated scope 3: 10,403 (Table 5.16)

$$x_{2017} = 0.48(10{,}403 + x_{2017})$$
$$x_{2017} = 4{,}993 + 0.48 * x_{2017}$$
$$x_{2017}\ 9{,}603\ tCO2e$$

- 2018: Calculated scope 3: 9,379 (Table 5.16)

$$x_{2018} = 0.48(9{,}379 + x_{2018})$$
$$x_{2018} = 4{,}501 + 0.48 * x_{2018}$$
$$x_{2018}\ 8{,}657\ tCO2e$$

- 2019: Calculated scope 3: 8,320 (Table 5.16)

$$x_{2019} = 0.48(8{,}320 + x_{2019})$$
$$x_{2019} = 3{,}994 + 0.48 * x_{2019}$$
$$x_{2019}\ 7{,}680\ tCO2e$$

- 2020: Calculated scope 3: 6,639 (Table 5.16)

$$x_{2019} = 0.48(6{,}639 + \ x_{2019})$$

$$x_{2019} = 3{,}186 + 0.48 * x_{2019}$$

$$x_{2019}\ 6{,}128\ tCO2e$$

Table 6-13: Calculated scope 3 and total emissions (without procurement emissions)

Year	Scope 1 (tCO2e)	Scope 2 (tCO2e)	Scope 3 (tCO2e) (from table 5.13, 5.14)	Total emission tCO2e
2015	3,307	5,928	NA	NA
2016	3,579	4,751	11,510	19,840
2017	2,893	3,769	10,303	16,965
2018	3,150	3,023	9,314	15,487
2019	2,912	2,721	8,320	13,953
2020	2,974	2,339	6,583	11,896
2021	3,505	2,110	274	5,889

The RGUs procurement emission is calculated using equation 6.1 and table 6-13. The resulting procurement emissions, scope 3 emissions, and total emissions are shown in table 6-14.

Table 6-14: Calculated scope 3 and total emissions (with procurement emissions)

Year	Procurement emissions (tCO2e)	Updated scope 3 (tCO2e)	Updated total emissions (tCO2e)
2016	10,750	22,396	30,590
2017	9,603	20,006	26,568
2018	8,657	18,036	24,144
2019	7,680	16,000	21,633
2020	6,128	12,767	18,024
2021	0 (estimate)	274	5889 (estimate)

Table 6.14 demonstrates that the emissions from the procurement emissions are nearly equal to the total emissions from the grid and travel. Although the results of the procurement are of low confidence, this method provides a good concept to understand the the range of the procurement

emissions. Ignoring procurement emissions can result in a very serious underreporting of scope 3 and total emissions.

6.5 Uncertainty and COVID impact on scope 3 emissions

The estimation of emissions in this research is based on benchmarking and peer analysis, as actual values are unknown. As such, it is not possible to calculate errors, which represent the difference between the actual and calculated values. However, uncertainty analysis can be used to determine the range within which the actual values may lie (Cohen, 1996). Nonetheless, estimating uncertainty is challenging in the absence of primary data.

It is assumed in this study that the reporting of scope 1 and scope 2 emissions by RGU is correct, although the quality of this reporting has not been evaluated. However, there may be underreporting or non-reporting of specific emission sources, leading to potential uncertainty in scope 1 and scope 2 emissions. It is recommended that a separate study be conducted to assess the accuracy of scope 1 and scope 2 emissions reporting. Errors or uncertainties in scope 1 and scope 2 emissions directly affect the total and procurement emissions calculations. Equation 6.1 demonstrates that the total emissions value is used to estimate procurement emissions. Therefore, any errors or uncertainties in scope 1 and scope 2 emissions will propagate to the total and procurement emissions estimations.

Uncertainty in commute emissions

The estimation of RGU's commute emissions using GCU's normalised commute emissions relies on the reliability and validity of the GCU survey data, as well as the assumptions made in the study. However, there are important differences between GCU and RGU, particularly in terms of their city layouts. GCU is situated close to the Glasgow city centre, while RGU is located 3.5 miles away. This difference in campus location may result in variations in student and staff commuting patterns between the two universities.

It is assumed that GCU students predominantly live near the university, while RGU students are more likely to reside further away. If this assumption holds true, RGU's commute emissions would be higher than those of GCU. The campus location disparity may indeed have an impact on the commuting behaviors of students and staff members, leading to potential uncertainties in the estimation.

To address these uncertainties and improve the robustness of commute emissions estimation, it is recommended to conduct regular commute surveys with an adequate sample size. By collecting primary data through these surveys, which are more reliable and accurate, the uncertainties associated with assumptions and extrapolations can be mitigated. Conducting such surveys on a half-yearly basis would provide valuable insights into the commuting patterns of RGU's students and staff, allowing for more accurate estimations of commute-related emissions.

Uncertainty about students' international trip

Table 6-7 provides a breakdown of the major continents from which overseas students have arrived. The assumption made in this study is that each student takes only one trip back home per year, which may be considered conservative. In reality, some students may make multiple trips in a year, while others may have a longer interval between trips, such as one trip every two years. Additionally, the calculation does not account for the visits of students' family members to the campus or city.

To address the uncertainty surrounding the number of trips made by international students and their associated emissions, conducting a survey specifically targeting international students would be beneficial. This survey could gather data on the frequency of their trips back home and any additional travel undertaken by their family members. By collecting primary data through such a survey, the estimation of international student travel emissions can be improved, reducing the uncertainties related to assumptions and generalizations. This survey would complement the existing commute survey and provide a more comprehensive understanding of the travel patterns and emissions of international students at RGU.

Uncertainty of business trip

To estimate RGU's business travel emissions, the normalised GCU business emissions were utilized. However, it should be noted that there may be significant variations between RGU and GCU in terms of their research and teaching profiles, as well as geographical areas of focus. These variations can have a considerable impact on business travel emissions. For instance, emissions can differ depending on whether academics are working within the EU or on long-haul international flights, with the latter having higher emissions.

Research studies have indicated that professors tend to undertake more business trips than early career academics. Therefore, understanding the staff academic profile at RGU in detail can help in capturing this relationship accurately. Any deviations from these assumptions can alter the estimation of RGU's business travel emissions.

Regarding data collection, there are two main approaches: (a) bottom-up travel record and (b) data from booking agents or services. Studies, such as the one by Wynes and Donner (2018), suggest that the bottom-up approach provides more accurate results compared to relying solely on data from booking agents. To reduce uncertainty, digital technology can be employed to streamline and manage the travel system. By using software that maintains comprehensive travel records and facilitates trip approval, ticketing, and management, the accuracy and reliability of business travel data can be greatly improved. Implementing such a system can be beneficial for conducting a robust analysis of business travel emissions and mitigating uncertainties in the estimation process.

Uncertainty of procurement emissions

The estimation of RGU's procurement emissions is based on the study by L Ozawa-Meida et al. (2013), which focused on De Montford's procurement emissions using input-output analysis. It is important to note that De Montford's profile differs significantly from RGU's profile, with variations in student enrollment and other factors. However, by expressing procurement emissions as a percentage of scope 3 and total emissions, some of the scale problems can be mitigated. There are several factors that can influence procurement emissions, such as the procurement supply chain, construction and retrofit activities within the campus, laboratory operations, and temperature control. These factors should be considered when estimating procurement emissions.

To reduce uncertainty in the estimation of RGU's procurement emissions, a more direct approach can be taken by calculating emissions directly from primary procurement data. Procurement data, including expenditure information, is typically available in an organisation's accounts and financial statements. This data can be used as input for input-output analysis, which requires technical training to understand and implement the calculations. By using primary data and implementing appropriate analysis techniques, the uncertainty associated with procurement emissions estimation can be minimized.

7. Benchmarking of HEI scope 3 emissions reporting

7.1 Scope 3 reporting based HEI benchmarking

Chapter 6 provides a detailed methodology for calculating HEI scope 3 emissions, focusing specifically on RGU, and explores the impact of COVID-19 on reducing these emissions. Chapter 4 presents a comprehensive study of scope 3 emissions for each HEI in Scotland over a five-year period. The chapters integrate information on measurement, reporting, challenges, and uncertainties associated with scope 3 emissions.

The next step in this research is to benchmark the performance of Scottish HEIs in reporting scope 3 emissions. The benchmarking process assesses HEIs based on the quality of their reporting, including factors such as completeness, consistency, inclusions, and accuracy. By benchmarking, HEIs can identify areas for improvement and focus on enhancing the quality of their reporting. Regular benchmarking exercises can enable HEIs to refine their reporting structures and enhance measurement accuracy.

Consistent and high-quality reporting of scope 3 emissions offers several benefits. It ensures greater accuracy in reporting, allows for meaningful comparisons between institutions, facilitates the adoption of best practices, and promotes innovation in emissions reduction strategies. By prioritising and improving reporting quality, HEIs can enhance their environmental performance and contribute to broader sustainability goals.

Table 7-1: RGU scope 3 emission and its proportion by source

Year/Scope 3 emission source	2016 (tCO2e)	2016 proportion	2017 (tCO2e)	2017 proportion	2018 (tCO2e)	2018 proportion	2019 (tCO2e)	2019 proportion
Procurement	10,750	48%	9,603	48%	8,657	48%	7,680	48%
Student commute	5170	23%	4855	24.3%	3961	22%	2868	18%
Staff commute	715	3.2%	666	3.3%	805	4.5%	941	5.9%
Student international trip	3674	16.4%	3248	16.2%	3180	17.6%	2905	18.2%
Business trip	1522	6.8%	1182	6%	1110	6.2%	1375	8.6%
Grid T&D	429.7	2%	352.37	1.8%	257.69	1.4%	230.99	1.4%
Water S&T	66.2	0.3%	81.1	0.4%	51.5	0.3%	45.3	0.3%
Recycle and waste	70.1	0.3%	19.5	0.1%	13.3	0.1%	10.6	0.1%
Total Scope 3 emissions	22,396	100%	20,006	100%	18,036	100%	16,000	100%

Table 7-1 presents scope 3 emission statistics for the years 2016 to 2019, providing a comprehensive breakdown of emissions from various sources. The data shows that procurement, student commute, and student international trips account for 87% of scope 3 emissions. Staff commute and business trips contribute 3.2% and 6.8% of scope 3 emissions, respectively. The consistent value of 48% for procurement emissions is attributed to the methodology used in the calculations.

It is crucial for all HEIs to report each emission source described in Table 5.18 to ensure consistency and avoid under-reporting of emissions. The reporting of all emission sources is a key component of the benchmarking process, along with sub-components such as whether the emissions are estimated or derived from primary data. The benchmarking framework assesses the 2019 data, and data consistency is evaluated for the years 2017, 2018, and 2019. The framework also considers the impact of COVID-19 on emissions in 2020 and 2021, scoring these years accordingly.

7.2 Impact of COVID lockdown on scope 3 emissions

The COVID-19 pandemic had a profound impact on HEI emissions, particularly during the nationwide lockdown period. The lockdown resulted in the closure of businesses, restrictions on travel, and a shift to remote work and online interactions. These measures significantly reduced operational activities and travel, leading to a reduction in scope 3 emissions for many HEIs.

During the academic year starting in September 2019, international students traveled to the UK, academics and research students made business trips, and routine procurement activities were underway. However, when the lockdown was enforced in March 2020, on-campus classes ended, staff and student commutes were reduced, and the use of Information Communication Technology (ICT) increased for staff and student interactions.

The reduction in staff and student commute emissions during the lockdown period can be estimated assuming a linear relationship. It is assumed that for the 2019-2020 academic year, commute emissions decreased by 50%, and for the 2020-2021 academic year, they decreased by more than 90%. However, the exact data on the initial lockdown stages and activity reductions are not known, so a conservative approach assumes at least a 25% reduction for 2019-2020 and an 85% reduction for 2020-2021 compared to the baseline year of 2018-2019.

The reporting format for HEIs during the COVID-impacted years varied. For example, the University of Aberdeen reported only certain components such as business trips, grid T&D, water S&T, and recycling, while other significant reductions in emissions from overseas travel, procurement, and staff/student commutes were not recorded. Additionally, there were discrepancies in the reported total emissions, making the data inaccurate and incomparable. It is important for HEIs to provide accurate and complete reporting, including all relevant emission sources.

Some HEIs successfully achieved the reduction targets for scope 3 emissions during the lockdown, while others fell short. The utilization of budget savings during the lockdown period and whether any additional funding was allocated to climate initiatives are important questions that require further investigation.

The COVID-19 pandemic forced the adoption of ICT solutions for daily activities, leading to reduced staff and student commutes, as well as decreased grid transmission and distribution emissions. This demonstrated that significant reductions in scope 3 emissions can be achieved through the reduction of commutes, travel, and procurement. However, it is important to note that the forced adaptation of ICT during the lockdown is not a sustainable long-term solution, and emissions are expected to rise as students and staff return to campus and normal activities resume.

Overall, the study raises questions about the emissions that occurred during the lockdown period, the utilization of budget savings, and the long-term sustainability of emission reduction measures. Further research is needed to address these questions and explore the potential for adopting digital technologies to reduce scope 3 emissions in a more sustainable manner.

7.3 Scoring of the emission source

The benchmarking equation is given by

$$s = \sum_{i=1}^{8} w_i * d ------EQ\ 5.2$$

$$Where\ w_i is\ the\ weight\ given\ to\ the\ each\ ith\ source$$

$$d\ is\ the\ score\ given\ to\ the\ each\ emission\ source$$

$$w_1 = 0.48\ (procurement)$$

$$w_2 = 0.21\ (student\ commute)$$

$$w_3 = 0.04\ (staff\ commute)$$

$$w_4 = 0.16\ (student\ international\ trip)$$
$$w_5 = 0.07\ (Business\ travel)$$
$$w_6 = 0.02\ (Grid\ T\&D)$$
$$w_7 = 0.01\ (Water\ S\&T)$$
$$w_8 = 0.01\ (Recycle\ and\ waste)$$

The individual emission source weights are derived from table 5.18

The equation for emission source score d is shown as

$$d = c + y + y_{21} + \ y_{22} - - - EQ\ 5.3$$

$$If\ the\ emission\ are\ not\ reported\ then\ d = 0$$
$$If\ the\ emission\ are\ estimated\ then\ c = 0.1$$
$$If\ the\ emission\ are\ calculated\ then\ c = 0.4$$

$$y = 0.2\ if\ the\ reporting\ is\ consistent\ for\ three\ consecutive\ years$$
$$y_{21} = 0.2\ if\ the\ emissions\ reduced\ by\ atleast\ 75\%\ from\ 2019$$
$$y_{22} = 0.2\ if\ the\ emissions\ reduced\ by\ atleast\ 95\%\ from\ 2019$$

Shown below are a few scoring examples with different combinations. The examples are for various scenarios for only one emission source: procurement.

Scenario 1

If the HEI has not reported the procurement emissions, then

d=0

p=0.48

Procurement emission score= 0*0.48=0

Scenario 2

If the HEI has reported the procurement emissions, which are not derived from data but an estimate. The HEI has also not shown a reduction in the years 2021 and 2022:

d=0.1

p=0.48

Procurement emission score= 0.1*0.48= 0.048

Scenario 3

If the HEI has reported the procurement emissions from either primary or secondary data and it has shown a reduction in the year 2020 but not in 2021. In addition, the reporting has been consistent for 3 years:

d=0.4+0.2+0.2= 0.8

p=0.48

Procurement emission score= 0.7*0.48= 0.384

Scenario 4

If the HEI has reported the procurement emissions, which are not derived from data but an estimate, it is reported consistently for 3 years. The emissions have not been reduced for the years 2020 and 2021:

d=0.1+0.2= 0.3

p=0.48

Procurement emission score= 0.3*0.48= 0.144

Scenario 4

If the HEI has reported the procurement emissions derived from data, they have reported consistently for 3 years. The emissions have been reduced for 2020 but not for 2021:

d=0.4+0.2+0.2= 0.8

p=0.48

Procurement emission score= 0.8*0.48= 0.384

Scenario 5

If the HEI has reported the procurement emissions derived from data, they have reported consistently for 3 years. The emissions have reduced in 2020 and 2021 proportionally:

d=0.4+0.2+0.2+0.2= 1

p=0.48

Procurement emission score= 1*0.48= 0.48

Scenario 6

If the HEI has reported an estimate in the first one or two years but reported emissions based on primary or secondary data in the last year, it shows that the HEI is improving its reporting structure. Therefore, the HEI is scored based on the last years reporting quality, and y=0.2 is added to the score.

For example, if an HEI reported procurement estimate for the first two years and a primary/secondary data calculation in the third year, then the third-year reporting is scored.

d= 0.8+0.2

p= 0.48

Procurement score = 1*0.48= 0.48

Scenario 7

Suppose the HEI has calculated the procurement emissions from primary or secondary data in the first two years and estimated the last year. In that case, it is assumed that the HEI has the capability and motivation to calculate the emissions with its data. Therefore, the full score is given to the HEI (as shown below)

d= 0.8+0.2

p=1

Procurement emissions score= 1* 0.48= 0.48

Only purchase emissions are included in the example of the seven possibilities above. There are eight different emissions sources listed in equation 5.2. Each emission source's score is added together to determine the HEI scores.

The benchmarking framework mentioned above takes into account the specifics of reporting, quality, consistency, and gradual improvement. It can also take into account any unforeseen events, such as the COVID lockdown. This framework is scalable to accommodate additional features and is transferable to other HEIs worldwide. The parameters w and d are highly flexible and configurable based on the scenario. The implementation of the benchmarking framework at the Scottish HEI is shown in this section. The benchmarking uses both the original and calculated RGU data. The actual data is referred to as RGU_i and the new calculated values are referred to as RGU_j.

Table 7-2: Benchmarking of Scottish HEIs

Universities	Procurement	Student commute	Student international trip	Staff commute	Business trip	Grid T&D	Water S&T	Recycle	Benchmarking score
Abertay University	0	0	0	0	0.007	0	0.008	0.05	0.065
Edinburgh Napier University	0	0	0	0	0.042	0.012	0.01	0.008	0.072
Glasgow Caledonian University	0	0.21	0.096	0.04	0.07	0.02	0.01	0.01	0.456
Heriot-Watt University	0	0	0	0	0.07	0.012	0.008	0.01	0.1
Queen Margaret University	0	0	0	0	0	0.012	0.006	0.008	0.026
RGU	0	0	0	0	0.042	0.012	0.008	0.01	0.072
SRUC	0	0	0	0	0.07	0.016	0.008	0.008	0.102
University of Aberdeen	0	0	0	0	0.07	0.004	0.004	0.008	0.086
University of Dundee	0	0	0	0	0.07	0	0.008	0.01	0.088
University of Edinburgh	0	0.168	0	0.032	0.07	0.004	0.008	0.008	0.29
University of Glasgow	0	0	0	0	0.07	0.016	0.008	0.006	0.1
University of HI	0	0	0	0	0.056	0.012	0.008	0.008	0.084
University of St Andrews	0	0	0	0	0.07	0.012	0.008	0.006	0.096
University of Strathclyde	0	0	0	0.016	0.07	0.016	0.008	0.008	0.118
University of Stirling	0	0	0	0	0	0	0.08	0.008	0.088
University of west Scotland	0	0	0	0	0	0	0.01	0.01	0.02
RGU-calculated	0.24	0.105	0.128	0.02	0.035	0.02	0.01	0.01	0.568

7.4 Benchmarking analysis for individual HEI

Based on the benchmarking framework, it is observed that 75% of Scottish HEIs scored 0.1 or less, indicating a relatively low level of performance in reporting scope 3 emissions. These HEIs predominantly reported emissions associated with business trips, grid T&D, water S&T, and recycling, which account for only 11% of scope 3 emissions. Therefore, it is unlikely that the benchmarking score would exceed 0.11 for these HEIs. Among these emissions sources, business trips carry the highest weight of 0.07, and HEIs like HWU and RGU received lower scores in this category, further reducing their overall benchmarking scores.

University of Stirling and SRUC achieved slightly higher benchmarking scores above 0.1. SRUC accurately reported low-impact emission sources, while University of Stirling included staff commute, which increased their score compared to other HEIs. Glasgow Caledonion University (GCU) and the University of Edinburgh were the only HEIs with respectable scores, receiving 0.46 and 0.29, respectively. GCU reported emissions from all sources except procurement, significantly boosting their score compared to their peers. On the other hand, the University of Edinburgh reported all emission sources except procurement and student international trips, which carry a high weight of 0.16 and can contribute to a higher benchmarking score. None of the Scottish HEIs reported procurement emissions for 2019, which holds a weight of 0.48 in the benchmarking framework.

Chapter 6 demonstrates how HEI emissions, in the case of RGU, can be estimated from secondary data. Procurement, staff/student commute, and business travel were estimated based on values from GCU, while international student trips were calculated using primary data from HESA. The benchmarking scores reflect this, with international student trips receiving a weight of 0.8 and procurement, staff/student commute, and business travel receiving a score of 0.5. RGU fully reported the other minor emission sources.

The benchmarking exercise highlights areas for improvement in reporting scope 3 emissions on a yearly basis. HEIs should focus on calculating or estimating procurement emissions, which carry a weight of almost 0.5. Travel-related emissions, particularly student commutes and international trips, are also important areas to address. While student international trips can be calculated using HESA data under specific assumptions, student commute requires survey analysis. Staff commuting and business travel are additional sources of emissions related to travel, and although many HEIs reported their business travel emissions, there is room for improvement. Consistently achieving a score of 1 over several years indicates streamlined reporting of scope 3 emissions, aligning it with the reporting of scope 1 and scope 2 emissions.

8. Conclusion

The thesis aimed to address the challenges associated with estimating scope 3 emissions and develop a strategy to overcome these challenges. It started by conducting a comprehensive investigation of HEI emissions on scopes 1, 2, and 3 at a UK-wide level. The focus then shifted to Scottish HEIs, with an emphasis on the accuracy, consistency, and quality of scope 3 reporting.

The classification of HEIs into clusters based on the percentage of scope 3 emissions reported and the foundation year revealed interesting patterns. HEIs in Cluster 1, with low scope 3 emissions percentages, tended to underreport their emissions. On the other hand, HEIs in Clusters 3 and 4, with a high proportion of scope 3 emissions, had covered a wider range of scope 3 emissions sources. However, it was observed that none of the HEIs had disclosed all critical emissions sources for scope 3.

Furthermore, the founding year of the HEIs was considered in the analysis. Newer universities generally have more energy-efficient facilities, while older universities may have older buildings that are not as energy-efficient. This comparison provided additional insights into the emissions profiles of different HEIs.

Overall, the research objectives outlined in Chapter 1 were effectively addressed in this study, bridging the knowledge gap and providing valuable insights into scope 3 emissions reporting in Scottish HEIs).

8.1 Research objectives and new knowledge

8.1.1 Exploratory data analysis of scopes 1, 2 & 3

The findings of the investigation revealed that several factors were highly correlated with scope 1 and scope 2 emissions in HEIs. These factors included total gross internal area, total staff FTE, research student FTE, non-residential income, total expenditure, water consumption, and energy consumption. This correlation analysis was conducted using HESA data, and only a small amount of scope 3 emissions reporting was required. As a result, a correlation analysis for scope 3 emissions was not performed in this study.

Among the factors analysed, energy consumption had the highest correlation with emissions, which aligns with previous studies by Ward et al. (2008) and Pérez-Lombard (2008). This suggests that decoupling the growth of HEIs from fossil fuel dependency is crucial to reduce emissions. One way to achieve this is by gradually replacing fossil fuel sources with renewable energy. Although the correlation between energy consumption and emissions may still be high, the normalised emissions will significantly decrease, contributing to the net zero targets.

After energy consumption, the area (total gross internal area and total site area) showed the highest correlation with scope 1 and scope 2 emissions. This highlights the importance of considering building and site characteristics in emissions reduction strategies. The UK HEI aims to reduce emissions by 43% compared to the baseline year of 1990 by 2020. However, as of 2019, HEIs had achieved a 35% reduction in emissions. The COVID-19 lockdown in 2020 had an impact on emissions, and therefore, 2019 is considered the target year. Moving forward, HEIs not only need to compensate for missed targets but also strive to meet the updated net zero targets.

The COVID-19 lockdown has provided new insights into how scope 3 emissions can be reduced, and this knowledge can guide future emissions reduction efforts in HEIs..

8.1.2 Scottish HEI scope 3 reporting analysis

The investigation conducted on Scottish HEIs in Chapter 5 revealed important findings regarding the accuracy, consistency, and reporting of emissions. The results showed that the majority of HEIs tend to report only a limited number of emissions sources, such as grid T&D, water S&T, recycling, and garbage, which collectively contribute to only 11% of scope 3 emissions. This selective reporting approach led to eight out of seventeen HEIs reporting scope 3 emissions that accounted for less than 20% of their total emissions.

Furthermore, it was identified that some HEIs incorrectly reported certain emissions sources, such as grid T&D, under scope 2 instead of scope 3. These errors can be attributed to human mistakes and a lack of proper training in emissions reporting, which can be addressed through immediate corrective measures to improve the overall reporting quality.

Interestingly, the ancient HEIs, including the University of Edinburgh, St Andrews University, and the University of Stirling, reported more travel-related emissions sources compared to the modern HEIs. This indicates that the older universities are more proactive in including a wider range of emission sources in their reporting.

The study also highlighted the significant contribution of travel-related and procurement emissions to scope 3 emissions, accounting for 89% of the total. However, there is weak evidence to suggest that HEIs are actively estimating these emissions. Commute emissions, for instance, require extensive surveys of both staff and students, while business travel data can be obtained from HEI finance records, travel agents, or insurance companies. Although fourteen out of seventeen HEIs reported their business-related emissions, none of them reported their commute emissions.

These findings emphasise the need for HEIs to improve their estimation and reporting of travel-related and procurement emissions, as these are major contributors to scope 3 emissions. Conducting comprehensive surveys for staff and student commutes and utilizing available data sources for business travel can help enhance the accuracy and completeness of scope 3 emissions reporting.

9.1.3 Estimating scope 3 emissions for RGU

In the case of thirteen out of seventeen HEIs, only emissions from business travel, grid T&D, water S&T, and recycling were reported. For RGU, University of Stirling, and University of West of Scotland, they reported even fewer emissions sources, specifically grid T&D, water S&T, and recycling, which account for less than 5% of the total scope 3 emissions. It is likely that there are other HEIs outside of Scotland facing a similar situation, where their scope 3 emissions reporting is limited.

To estimate the full scope 3 emissions for HEIs with limited data, such as RGU, deductive reasoning is used in this research. The first step is to find a peer institution with similar characteristics to RGU. By comparing factors such as budget, research budget, number of students, personnel, international students, and research subjects, a suitable peer can be identified. The emissions of this peer institution are then normalised, and the ratio is applied to estimate RGU's emissions.

Whenever primary or secondary data is available, scope 3 emissions are directly calculated from that data. However, when primary or secondary data is unavailable, the scope 3 emission ratio from the identified peer institution is used for estimation. For example, in the case of RGU, procurement emissions are estimated based on secondary data, while commute emissions are calculated using peer analysis. International student emissions are estimated using primary data.

This approach allows for the estimation of scope 3 emissions even when there is limited data available. By leveraging the characteristics and emissions data from peer institutions, a reasonable estimate can be made for HEIs with incomplete reporting..

8.1.4 Benchmarking of the Scottish HEI based on their scope 3 emissions reporting

The development of a novel scope 3 emission quality framework has provided HEIs with a tool to assess their performance in reporting scope 3 emissions. This framework takes into account variables such as data quality, consistency over time, the impact of COVID-19, and data completeness. The benchmarking score ranges from 0 to 1, with 0 indicating poor performance and 1 representing excellent performance.

The benchmarking exercise revealed discouraging results for most Scottish HEIs, with GCU and University of Edinburgh being the best-performing institutions. GCU achieved the highest score of 0.47, while University of Edinburgh had a score of 0.29. For RGU, the estimated scope 3 emissions received a benchmarking score of 0.57. It is important to note that no HEI can surpass a benchmarking score of 0.52 without reporting procurement emissions, as procurement carries the highest weight in the scoring system. HEIs can utilize the benchmarking scores to identify areas for improvement. Taking RGU as an example, their benchmarking scores indicate the need to focus on reporting procurement emissions and minimizing commute-related emissions. It is worth noting that RGU received a near-perfect score for grid T&D, water S&T, and recycling, suggesting that their efforts should be directed towards other emission sources.

By analysing the benchmarking scores, HEIs can gain insights into specific areas of improvement and work towards enhancing their performance in reporting scope 3 emissions.

8.1.5 Impact of COVID

The study observed that the COVID-19 lockdown had a positive impact on scope 3 emissions. With the nationwide lockdown, there was a significant reduction in commuting emissions as workers and students did not have to travel. Moreover, business and international student travel were also halted during this period. The thesis assumed that scope 3 emissions should decrease by at least 25 percent in 2020 and 75 percent in 2021 due to the lockdown.

However, it was noted that several HEIs did not demonstrate a substantial decrease in scope 3 emissions during these years. For example, RGU did not show any decline in grid T&D emissions. Given that the entire campus was shut down, it can be assumed that there should not have been any electricity-related emissions. HEIs that did not exhibit a significant reduction in scope 3 emissions in 2020 and 2021 may receive lower scores in the benchmarking framework as a penalty.

This finding highlights the importance of accurately reporting and tracking scope 3 emissions, especially during exceptional circumstances like the COVID-19 lockdown. HEIs should strive to align their reported emissions with the actual impact of such events to ensure accurate benchmarking and identify areas for improvement.

8.2 Further research

This study has uncovered numerous new research areas that can greatly advance understanding in scope 3.

1. Developing a simple framework to estimate procurement emissions in HEI.
2. Scaling up the benchmarking activity on UK-wide HEI.
3. How COVID impacted UK-wide HEI emissions.
4. Incorporating ICT emissions in scope 3, due to homeworking.
5. Clustering the HEI using a machine learning unsupervised model to identify peers.
6. Application of data envelopment analysis on the UK-wide HEI emissions data (benchmarking algorithm)
7. How the emissions have bounced back after the lockdown restrictions were lifted. Whether the lockdown had a temporary effect or it had a lasting impact

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