Bristol One City Climate Strategy

Total GHG emissions of the City of Bristol – Technical report

FINAL ISSUE
28th January 2020

ARUP BRISTOL ONE CITY

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Contents

1. Introduction

Overview

Arup, supported by the University of Leeds, has been commissioned to undertake a high-level study to quantify total greenhouse gas (GHG) emissions of organisations and businesses in the City of Bristol. This assessment is focussed on an evaluation of emissions that arise from public sector, private sector and third sector Bristol-based organisations.

This study was commissioned by Bristol City Council (BCC) to provide evidence to feed into the Bristol One City Climate Strategy. The evaluation contributes to the city's understanding of baseline emissions for businesses in the City of Bristol and the scale of mitigation interventions required to reach net zero by 2030.

The purpose of this study is to provide an evidence base upon which to establish areas of greatest required action in the journey to net zero, estimating the scale of progress needed in each business sector and establish immediate next steps in the journey to net-zero for Bristol's businesses. This evidence will also be referred to in the development of strategic objectives and city-wide future action the Bristol One City Climate Strategy.

This work will be followed by a series of six illustrative case-studies that will present a focused view of emissions of organisations in Bristol. The case studies will represent a spread of organisations across different sectors.

Each of these outputs will help to provide a baseline for and feed into the development of the Bristol One City Climate Strategy.

Context

Bristol is home to 18,300 organisations and businesses ~16,100 of which are micro organisations (0-10 employees) demonstrating the city's wealth of independent businesses. Completing the portfolio, Bristol hosts ~2,100 SMEs (10-250 employees) and 90 large (250+ employees) organisations *(ONS, 2019)*.

Bristol has a predominantly service-based economy with ~8,700 businesses providing professional, technical, financial and administrative support. The city also has a strong trade culture with ~3,000 businesses offering wholesale, retail and food/drink related products *(ONS, 2019)*. The complete portfolio of Bristol's businesses annually contribute £925m to the UK's economy in terms of Gross Value Added (GVA) *(ONS, 2018)*.

BCC was the first UK council to declare a climate emergency for the city on 13th November 2018. BCC has also set an ambitious goal of making Bristol carbon neutral and climate resilient city by 2030 (*CEUK, 2019*). This goal will have a significant impact on the operational approach of all businesses in Bristol.

A number of businesses, organisations and institutions in the city have declared a climate emergency including the University of Bristol, North NHS Trust and University Hospitals NHS Foundation, We the Curious, the Watershed, The Old Vic and the Colston Hall.

This study adds to the climate change adaptation and mitigation evidence base and can provide evidence to support wider climate action in the city.

Approach to the study

The Intergovernmental Panel on Climate Change (IPCC) has produced assessment reports since 1990 that synthesise published literature and research on climate change. This has shown that global average temperatures have increased by 0.85°C since 1850 (in the range 0.65–1.06°C) (*Stocker et al, 2013*). Much of this change is directly linked human activity and the continued emission of greenhouse gases into our atmosphere through various industrial processes (*IPCC, 2014*).

The Greenhouse Gas Protocol for Cities *(GHGP, 2014)* and PAS 2070 *(BSI, 2013)* are globally recognised industry standards and specifications (respectively) that provide guidance on reporting against and monitoring those emissions. The standards themselves are shaped around the Intergovernmental Panel on Climate Change guidelines for greenhouse gas inventories *(IPCC, 2006).* This study uses the guidance provided in those international standards to evaluate the total GHG footprint of the City of Bristol.

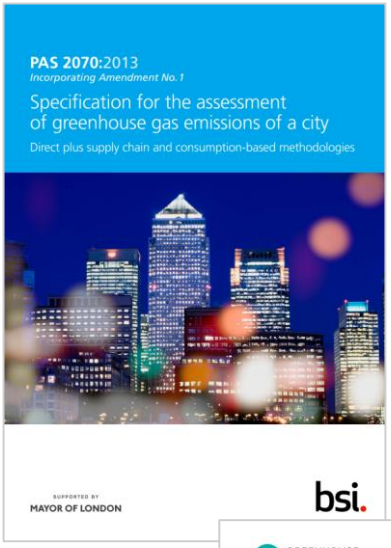

Figure 1: PAS 2070 *(BSI, 2013)*

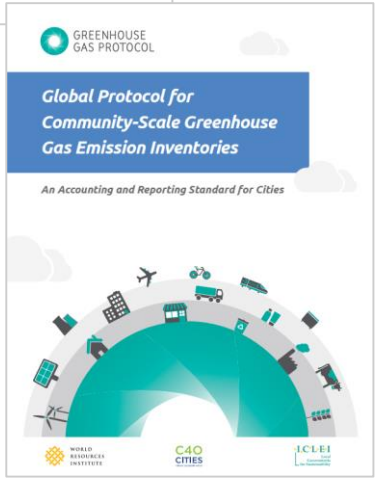

Figure 2: The Greenhouse Gas Protocol for Cities *(GHGP, 2014)*

2. PAS 2070 and the Greenhouse Gas Protocol for Cities
An overview

Introduction

The approach taken for this study is aligned to the emissions reporting requirements outlined in the Greenhouse Gas Protocol for Cities (GPC) *(GHGP, 2014)* and PAS 2070 *(BSI, 2013)*. The GPC is a global standard for GHG emissions reporting of cities, while PAS 2070 was developed by the British Standards Institution (BSI) and therefore provides guidance for a UK focused approach. PAS 2070 builds on the guidance of the GPC and as a result, the standards complement each other to describe a consistent approach to city-wide GHG reporting and evaluation.

This study employs the GPC standard to set the boundaries for the study and PAS 2070's specific guidance for emissions calculation methods.

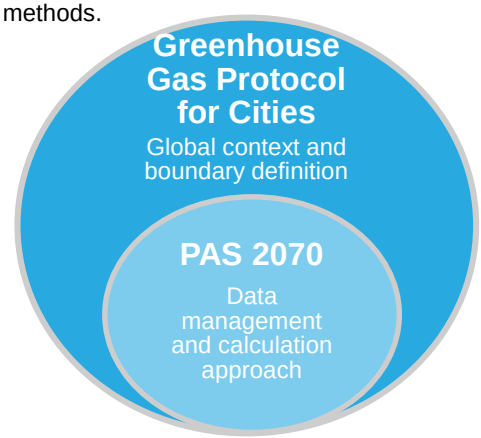

Figure 3: Alignment to industry standards for greenhouse gas emission reporting

Setting inventory boundaries with GPC *(GHGP, 2014)*

The GPC was developed through collaboration between the GHG Protocol at World Resources Institute (WRI), C40 Cities Climate Leadership Group (C40), and ICLEI—Local Governments for Sustainability (ICLEI). The standard is intended to be used for greenhouse gas emissions assessments of geographically defined areas and cities in particular.

The GPC calls for all studies to first define the scope of assessment in terms of: geographic boundary, time period and emissions sources. Any geographic boundary can be used so long as the boundary remained consistent in future reporting and tracking activities.

Geographic boundaries may align to administrative boundaries, boroughs, wards or a combination of administrative divisions. Consistent reporting is made easier if these boundaries are legally defined and recognised rather than established solely for the purpose of the study.

The GPC is designed to account for city GHG emissions occurring over a 12-month period (this is also true for the methodology outlined in PAS2070).

To allow cities to distinguish between emissions that occur both inside and outside the defined city boundary as a result of activities occurring within the city, the GPC has defined three emissions scopes. The scopes and associated emissions sectors that fall within them are as described here and depicted below in Figure 4. A breakdown of the GPC defined emissions sectors can be found in the GPC itself *(GHGP, 2014)* and summarised in Figure 5 on page 6.

Scope 1: These greenhouse gas emissions arise from direct sources and activities occurring within the city boundary.

Scope 2: Emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the city boundary.

Scope 3: All other emissions that occur outside of the city boundary as a direct result of activities taking place within the city boundary are included within this category.

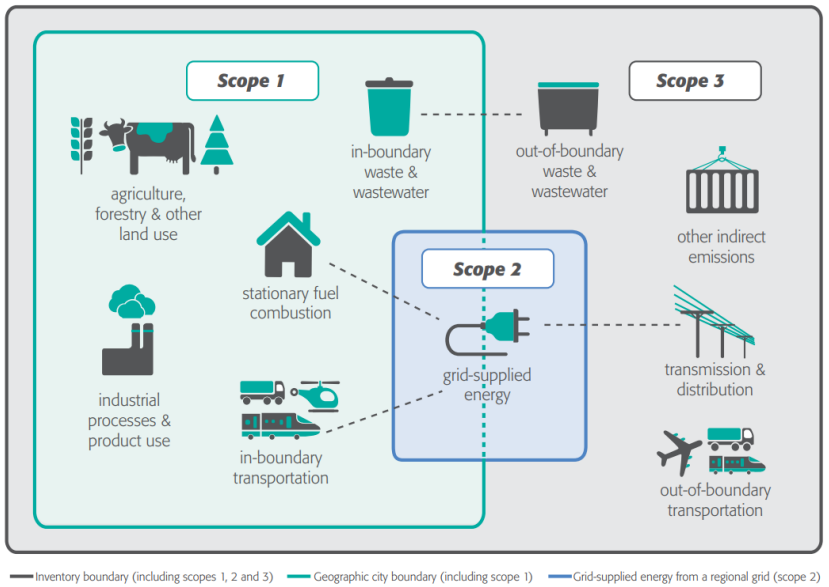

Figure 4: Sources and boundaries of city GHG emissions *(GHGP, 2014)*

2. PAS 2070 and the Greenhouse Gas Protocol for Cities
An overview

Calculating emissions with PAS 2070 *(BSI, 2013)*

The development of PAS 2070 was sponsored by the Greater London Authority and conducted by the British Standards Institution (BSI). The steering group directing the development of PAS 2070 included, among others, organisations such as: the C40 Cities Leadership Group, ICLEI, Transport for London and the London Sustainable Development Commission.

PAS 2070 specifies requirements for the assessment of greenhouse gas (GHG) emissions of a city to encourage greater consistency of GHG reporting in cities. The overall guidance for city GHG reporting methodology is aligned to that stipulated in the GPC and includes the following stages: setting boundaries and scopes, data collection, GHG calculation and analysis and progress monitoring.

In the calculation and analysis phase, the industry standard recommends using an environmentally extended input-output (EEIO) model to calculate city-wide greenhouse gas emissions. An EEIO model makes use of data describing spending (consumption) of households and government, and business capital expenditure. This data is based on financial flow data from national and regional economic accounts. Using this expenditure data, EEIO models estimate GHG emissions using average GHG emission factors for each consumption category depending on where the goods and services consumed in the city are produced (i.e. in the city, rest of the country, or rest of the world).

Monitoring and review

Both the GPC and PAS 2070 specify annual reporting and review of emissions in order to accurately monitor change and progress in footprint reduction. However, given the slow moving nature of industry with respect to actively reducing GHG emissions, bi-annual review may be beneficial in ensuring regular progress monitoring and identification of opportunities for change and adaptation.

More detail on specific reporting requirements can be found in the specifications themselves.

Sectors and sub-sectors	Scope 1	Scope 2	Scope 3
STATIONARY ENERGY			
Residential buildings	✓	✓	✓
Commercial and institutional buildings and facilities	✓	✓	✓
Manufacturing industries and construction	✓	✓	✓
Energy industries	✓	✓	✓
Energy generation supplied to the grid	✓		
Agriculture, forestry, and fishing activities	✓	✓	✓
Non-specified sources	✓	✓	✓
Fugitive emissions from mining, processing, storage, and transportation of coal	✓		
Fugitive emissions from oil and natural gas systems	✓		
TRANSPORTATION			
On-road	✓	✓	✓
Railways	✓	✓	✓
Waterborne navigation	✓	✓	✓
Aviation	✓	✓	✓
Off-road	✓	✓	
WASTE			
Disposal of solid waste generated in the city	✓		✓
Disposal of solid waste generated outside the city	✓		
Biological treatment of waste generated in the city	✓		✓
Biological treatment of waste generated outside the city	✓		
Incineration and open burning of waste generated in the city	✓		✓
Incineration and open burning of waste generated outside the city	✓		
Wastewater generated in the city	✓		✓
Wastewater generated outside the city	✓		
INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)			
Industrial processes	✓		
Product use	✓		
AGRICULTURE, FORESTRY AND OTHER LAND USE (AFOLU)			
Livestock	✓		
Land	✓		
Aggregate sources and non-CO_2 emission sources on land	✓		
OTHER SCOPE 3			
Other Scope 3			

✓ Sources covered by the GPC
Sources required for BASIC reporting
+ Sources required for BASIC+ reporting
Sources required for territorial total but not for BASIC/BASIC+ reporting (*italics*)
Sources included in Other Scope 3
Non-applicable emissions

Figure 5: GPC defined emissions sectors *(GHGP, 2014)*

3. Methodology

Contributing to the evidence base

The results established in this report, along with others, contribute to the evidence and engagement base upon which Bristol's One City Climate Strategy has been built.

The climate mitigation evidence base is made up of three reports (including this one) and works to describe the baseline of greenhouse gas emissions in Bristol. Each report views the evidence base through a slightly different lens, with different methods and authors, but together they provide a good idea of our current emissions and their sources. The approach and overlap of each study is described below and detailed in Figure 6.

Arup – business emissions:

Making use of the validated and trusted UK-MRIO model of the UK economy developed by the University of Leeds, Arup conducted a top-down assessment of the total (scopes 1, 2 and 3) emissions of Bristol's economy. The results describe emissions associated with business activities in based on the UK total scaled down according to GVA of ONS industry sectors in Bristol.

University of Leeds – consumer emissions:

Using the same method as was adopted in this study, the University of Leeds conducted a top-down assessment of direct (in city) and indirect (out of city) emissions associated with the production of goods and services consumed per capita by residents of Bristol.

Centre for Sustainable Energy (CSE) – City-wide scope 1 and 2 emissions:

This study builds on work undertaken by Regen and uses a bottom-up approach to establish actions required to get to net zero when looking at scope 1 and 2 emissions in the city. Emissions sources covered in this study include: direct fossil-fuel energy use within the city (principally in vehicle engines, heating boilers and cookers, and industrial processes including waste disposal, and the emissions associated with electricity used in the city (most of which has been generated elsewhere). Emissions associated with the production of materials have no been considered in the CSE report.

The findings of this robust evidence base have fed into the One City Climate Strategy.

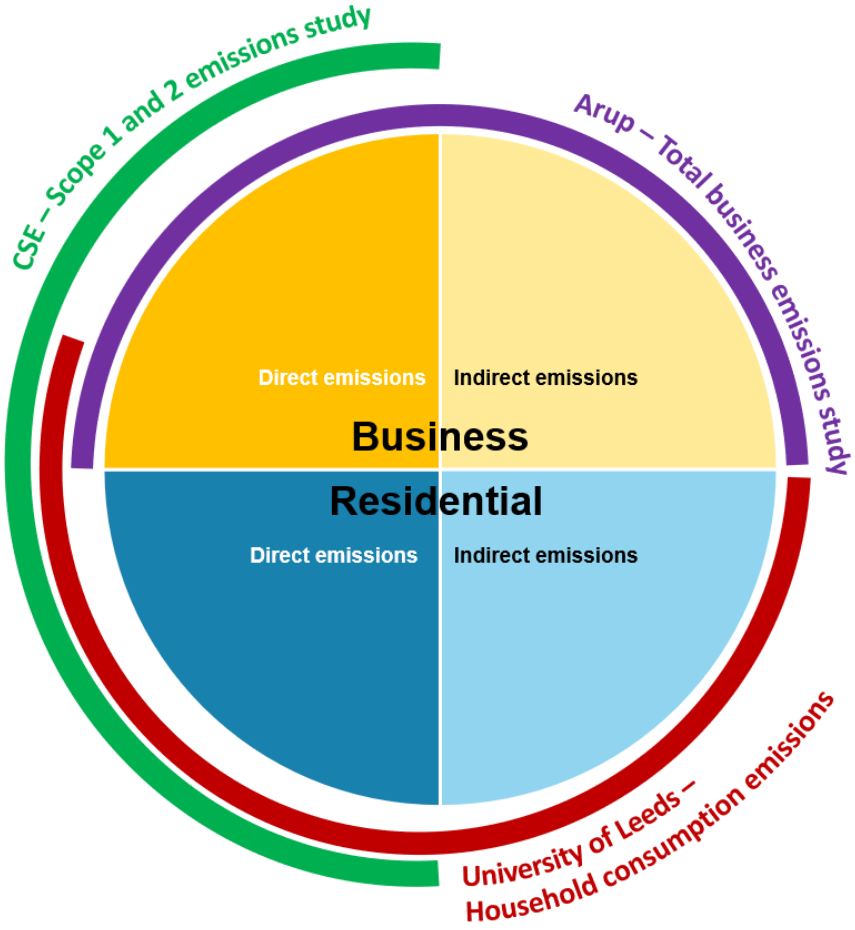

Figure 6: How our climate mitigation evidence bases work together

3. Methodology

Overview of approach

The overall approach taken to calculate the business footprint for Bristol is outlined below in Figure 7. As previously discussed, this methodology is aligned to the approach stipulated in the Greenhouse Gas Protocol for Cities (GPC) and PAS 2070.

The database used for the evaluation is the UK multi-regional input-output (MRIO) economic model developed by the University of Leeds *(Owen et al, 2018 and Sakai et al, 2017)*. This validated model has been used in multiple studies across the UK including material footprint and resource efficiency analysis publish by HMG Department for Environment, Food and Rural Affairs (DEFRA) *(Owen et al, 2019)*.

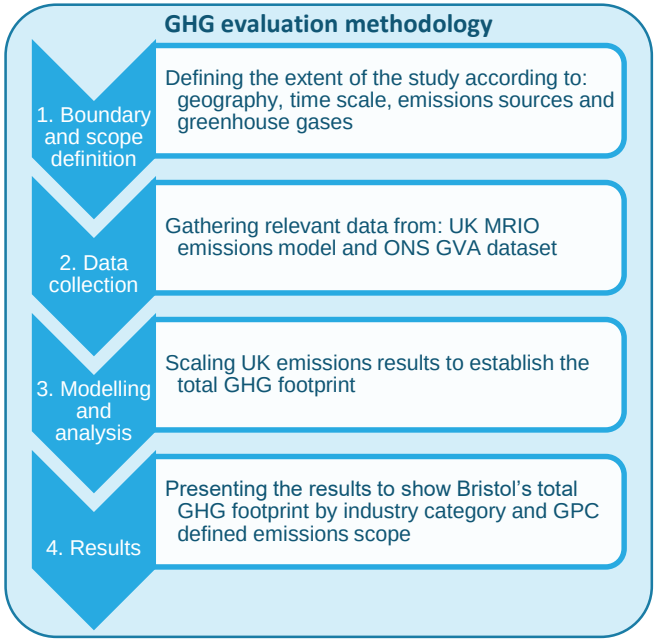

Figure 7: 4-step methodology to evaluation the total GHG emissions footprint of Bristol in accordance with GPC guidelines

1. Boundary and scope definition

As per the GPC, the first stage of this city-level GHG emissions study was to define inventory boundaries and scope categories for the analysis *(GHGP, 2014)*. This boundary defines the geographical limit, timescale, emission sources, and greenhouse gases to be considered in the analysis.

Boundaries employed for this study are as follows:

- **Geographic:** Bristol City Council local authority
- **Time scale:** 2016 (calendar year), to align with the latest available data in the UK MRIO model used for the study
- **Emission sources:** the GPC defines sources in 'sectors' *(GHGP, 2014)*. These GPC sectors where used in this study and are as follows:
  - Stationary energy
  - Transportation
  - Waste
  - Industrial processes and product use
  - Agriculture, forestry and other land use
- **Scopes:** GPC definitions of emissions scopes were also adopted for this study (see Figure 5). However, as the GPC provides guidance for reporting both commercial and citizen generated emissions within a city boundary, any emissions sources that refer to residential or individual GHG emissions have not been included in this study. For example, stationary energy from residential buildings has not been incorporated into the GHG evaluation.
- **Greenhouse gases:** All seven Kyoto protocol greenhouse gases *(UN, 1998)* were considered in this analysis.

2. Data collection

The UK Multi-Region Input-Output model developed by the University of Leeds was the main source of data collection for this study *(Owen et al, 2018 and Sakai et al, 2017)*. This is a validated and trusted model of the UK economy and its emissions characteristics, based on the national Supply and Use Tables (SUTs) published by the Office of National Statistics (ONS) *(ONS, 2018)*.

The UK MRIO model analyses spending from households, government and business capital expenditure based on the aforementioned ONS data to estimate greenhouse gas emissions. In the model, GHG emissions are calculated using average GHG emissions factors for each consumption category that depend on where the goods and services consumed in a city are produced *(Owen et al, 2018 and Sakai et al, 2017)*. This calculation approach aligns to the GPC recommended method for calculation of GHG emissions *(GHGP, 2014)*.

This study also drew on ONS data for annual regional GVA estimates to account for Bristol's contribution to national emissions. The ONS GVA data is split up into UK economic sectors, allowing for a sector level analysis of emissions arising from the economy *(ONS, 2018)*.

Data in the UK MRIO model is accurate for economic output and emissions in 2016. As such, this study made use of ONS GVA data from that same year to ensure consistency of approach.

3. Methodology

3. Modelling and analysis

Data preparation

The UK MRIO model data, upon which this study is built, reports emissions against 106 industry categories. These categories are based on the ONS UK Standard Industry Classification (SIC) codes *(ONS, 2009)* that are not directly aligned to the GPC defined emissions sectors and scopes. As such, the first exercise of our analysis for to map the UK MRIO industry categories against the GPC emissions sectors and scopes.

In one case, appropriate industry category mapping was not possible. According to the GPC guidelines, emissions from electricity generation are included under Scope 2, while emissions associated with electricity transmission and distribution fall under Scope 3 *(GHGP, 2014)*. In the UK MRIO model, data for electricity generation, transmission and distribution are reported in one industry category. As such, it was not possible to separate emissions from electricity generation, and those associated with transmission and distribution when allocating emissions to Scope 2 and Scope 3. The decision was taken to allocate this industry category to Scope 2. All other UK MRIO industry categories were successfully mapped to and reported against the GPC emissions sectors and scopes.

Data modelling and analysis

The overall approach to calculating the GHG footprint of is outlined in Figure 8.

First, the UK-focussed global input-output (UK MRIO) model developed by the University of Leeds was used to derive the business footprint for the UK, according to 2016 data. As a result of the top-down, zero-leakage, nature of input-output modelling, all sectors of the UK economy are represented in this analysis.

The full UK footprint was then scaled down using gross value added (GVA) data compiled by the Office for National Statistics (ONS) *(ONS, 2018)*, which enabled the derivation of the percentage contributions of Bristol City Council to total UK GVA by sector. The resulting business footprint covers all Bristol business activity in 2016 that served demand no matter where it is, and the emissions associated with the consumption of businesses from the global supply chain. The resulting footprint has been presented according to the GPC framework for reporting city emissions by scope and through a SIC code defined industry sector breakdown to provide two complementary perspectives on the city's carbon footprint.

Modelling assumptions

Scaling emissions according to GVA assumes that Bristol businesses are representative of the overall UK supply chains by sector in terms of emissions intensity. For example, that a Bristol-based biscuit factory operates at a comparable emissions intensity to the UK average for this sector.

The ONS GVA by industry category dataset did not have corresponding information for all 106 UK MRIO categories despite being based on the same SIC codes. As a result, some ONS GVA industry categories were grouped into aggregated categories. In these instances, the UK-GVA ratios for the aggregated categories were applied to each of the relevant UK MRIO industry categories.

4. Results

To deliver a high level understanding of the GHG footprint of Bristol, the results from this study have been presented in three formats:

A. Total GHG footprint of Bristol (in comparison to that of the UK)

B. Total GHG footprint of Bristol, split up into GPC emissions sectors scopes 1, 2 and 3

C. Total GHG of Bristol split up into industry sectors (according to SIC codes)

The results are described and explained in section 4.

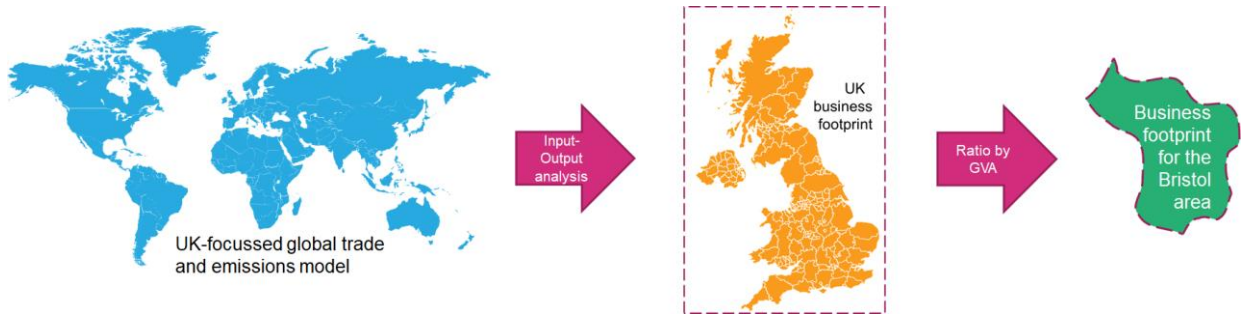

Figure 8: Data analysis process to establish the GHG footprint of Bristol

4. Results

Introduction

This study used ONS data describing UK regional and industry sectoral GVA in combination with emissions factors from a Leeds University developed multi-regional input-output model to establish business sector based greenhouse gas emissions in Bristol. The results are presented in the following arrangement:

A. Bristol's total (scopes 1, 2 and 3) GHG emissions in comparison to that of the UK

B. Bristol's GHG emissions according to GPC emissions scopes (1–3)

C. Total emissions in Bristol by industry sector

All analysis and results are based on data from 2016. Key messages from data analysis include:

- Bristol's total GHG footprint accounts for 0.64% of the UK's total footprint
- Direct (scopes 1 and 2) and consumption (scope 3) greenhouse gas emissions account for equal portions of Bristol's overall GHG footprint (see page 10)
- Manufacturing and production sectors are high GHG emitters in comparison to their contribution to Bristol's GVA (see page 11)

A. Bristol compared to the UK

As shown in Figure 9, the total greenhouse gas emissions attributable to the local authority of Bristol in 2016 summed ~5,000 $ktCO_2e$. This accounts for 0.64% of the UK's total GHG footprint which was ~776,000 $ktCO_2e$ in 2016. Table 1 outlines Bristol's contributions to the emissions, population and GVA of the UK. These figures indicate that Bristol's contribution to the UK's greenhouse gas footprint is in line with its proportion of the population. Bristol is responsible for 0.82% of the UK's total GVA and 0.64% of its business related emissions. This indicates that Bristol's GVA contribution is higher per percentage point of associated emissions. This reflects the predominantly service-based economy in and aligns to the results shown in Figure 11 (see page 12) which demonstrate that professional, financial, information and real estate business contribute significantly to Bristol's GVA with a comparatively low contribution to GHG emissions.

Further detail on the extent and origin of emissions in can be found in the data tables accompanying this report.

Table 1: GHG emissions, population and GVA of the UK and Bristol

Variable	UK	Bristol	/ UK (%)
GHG emissions* to the nearest '000 $ktCO_2e$	776,000	5,000*	0.64
Population** (no. of people)	65,648,054	454,213	0.69
Gross value added** (£m)	1,729,092	14,313	0.82

** (Owen et al, 2018 and Sakai et al, 2017)*
*** (ONS, 2018)*

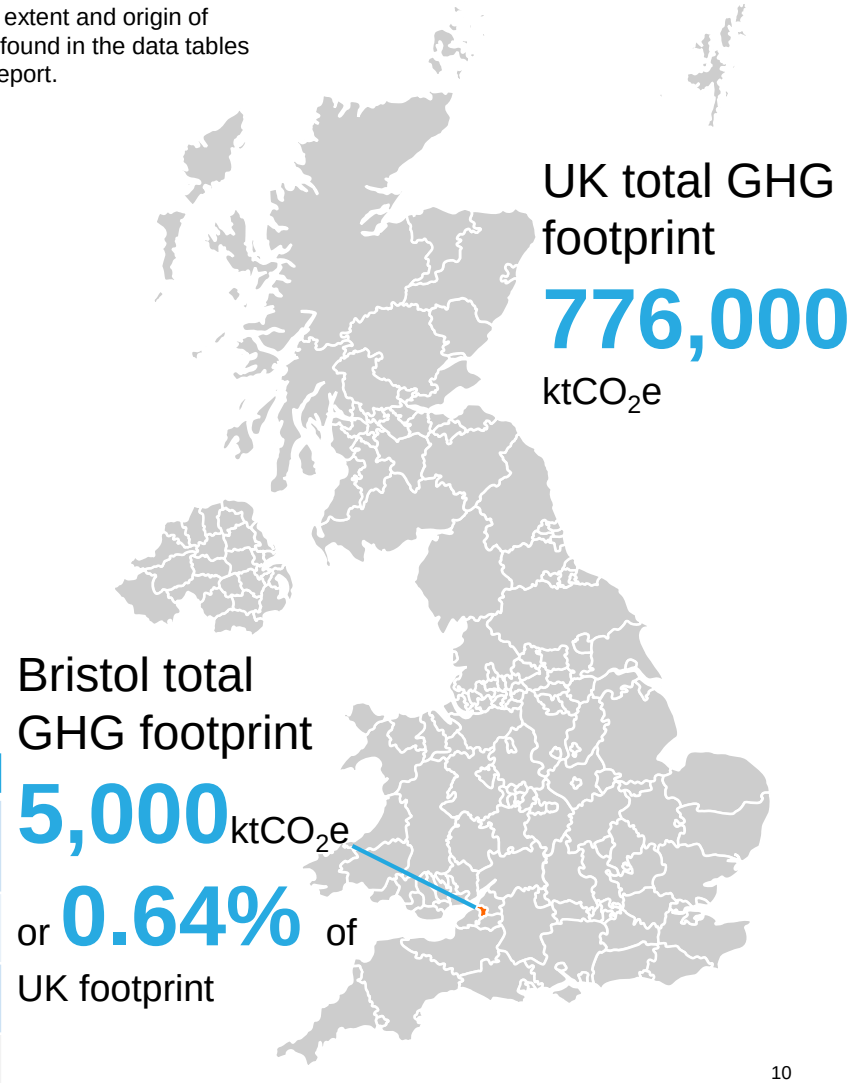

Figure 9: Total (scopes 1, 2 and 3) GHG emissions of the UK and Bristol

4. Results

B. Bristol GHG emissions by scope

The greenhouse gas protocol for cities (GPC) outlines three scopes for emissions sources *(GHGP, 2014),* with Scopes 1 and 2 accounting for territorial emissions. Definitions of those scopes are given in section 2 of this report.

Figure 10 indicates the proportion of Bristol's total greenhouse gas emissions that fall within each GPC emission scope and sub-sector. The results are presented in terms of $ktCO_2e$ within each emissions sub-sector (Table 2) and the percentage of Bristol's total GHG footprint for which that scope or sub-sector accounts (Figure 10).

Scope 1 emissions account for ~39% of Bristol's total business emissions, with the largest emission source within that group being 'stationary energy'. As per Figure 5 and the greenhouse gas protocol for cities *(GHGP, 2014)*, stationary energy accounts for all emissions occurring in Bristol as a direct result of: energy use in commercial buildings, energy consumption for manufacturing and construction and power generation within the city. This aligns to the GPC's analysis that stationary energy is one of the largest contributors to the overall GHG emissions.

Scope 2 emissions arising from the use of grid-supplied energy to Bristol businesses accounts for 11% of total economy GHG emissions. As per the definition on page 5, this includes emissions resulting from the consumption of grid supplied electricity as well as heat, steam and air conditioning. Emissions included in the scope 2 evaluation also cover those associated with the transmission and distribution of described energy sources. Given the National Grid's trajectory in delivering low-carbon electricity *(National Grid, 2018)*, the absolute value of this emission contribution (and the percentage contribution to Bristol's overall emissions) is likely to decrease in the future.

Scope 3 (occurring outside the city boundary) emissions account for approximately half of Bristol's total business footprint. Of this, the scope 3 'other indirect emissions' sub-sector is the largest contributor to Bristol's total business footprint when the emissions results are viewed in terms of GPC emissions categories *(GHGP, 2014)*. 'Other indirect emissions' are those associated with the production of goods and services that occur outside the city boundary as a direct result of commercial activities within the city boundary. For example, the emissions associated with the production of bricks in a factory outside Bristol that will be used for a construction project within the city boundary are accounted for in this group.

Emissions within this group occur outside the Bristol local authority boundary (as a direct result of commercial activities within Bristol) and arise from stationary energy, industrial processes, product use, agricultural activities and land use.

Further detail on the extent of emissions under scopes 1, 2 and 3 can be found in the data tables accompanying this report.

N.B. The BEIS sub-national data set for emissions describes Bristol's electricity and gas consumption associated emissions as 316 $ktCO_2e$ and 187 $ktCO_2e$ respectively *(BEIS, 2019)*. As outlined in the report, the scope for stationary energy and grid supplied electricity covers a wider range of emissions sources than described in the quoted sub-national dataset figures *(GHGP, 2014)*. This nuance, in combination with the top-down approach taken in this study and the fact that 62% of the BEIS data was established by proxy, are considered to account for the variance in emissions results.

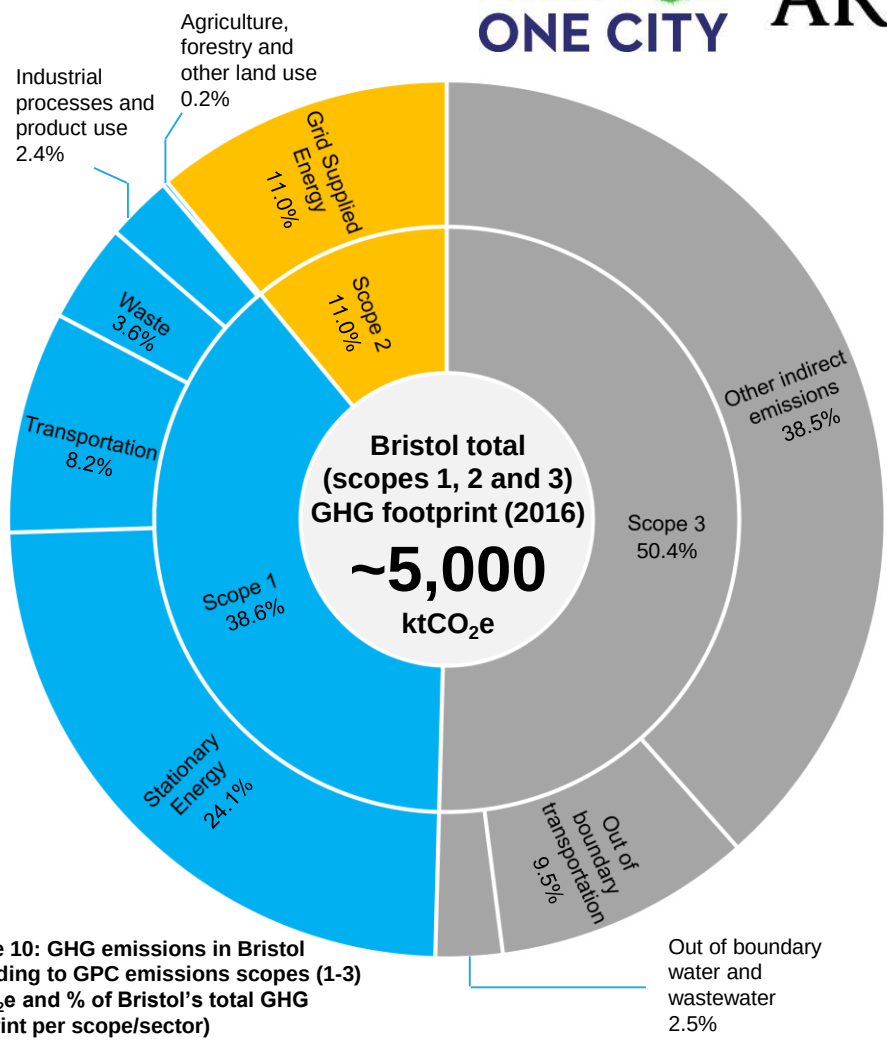

Figure 10: GHG emissions in Bristol according to GPC emissions scopes (1-3) ($ktCO_2e$ and % of Bristol's total GHG footprint per scope/sector)

Table 2: GHG emissions in Bristol according to GPC emissions scopes (1-3)

Scope	Emission source	Bristol GHG emissions ($ktCO_2e$)
1	Stationary Energy	1272
	Transportation	432
	Waste	193
	Industrial Processes & Product Use	129
	Agricultural Forestry & Land Use	10
2	Grid Supplied Energy	581
3	Other indirect emissions	2030
	Out of boundary transportation	501
	Out of boundary waste & wastewater	130

4. Results

C. Bristol business GHG emissions by industry sector

The emissions results in Figures 11 and 12 are presented in terms of industry sectors. The industry sectors align with the Standard Industrial Classification (SIC) groupings *(ONS, 2009)* used by the Office for National Statistics (ONS) in their regional GVA reporting dataset *(ONS, 2018)*. The letters next to each industry sector refer to the relevant SIC groups (and associated activities) that are reported in each sector.

Figure 12 shows the percentage of Bristol's total (scopes 1, 2 and 3) GHG footprint associated with each of the industry sectors.

Production, manufacturing, distribution and the provision of public services account for 82% of Bristol's business and economy footprint. Each of these sectors is discussed in more detail on pages 13-15.

Figure 11 shows the proportion of Bristol's total GVA that can be attributed to each industry sector alongside the emissions percentages outlined in Figure 12. Sector descriptions are outlined in the UK Standard Industrial Classification of Economic Activities *(ONS, 2009).* This comparison indicates that the percentage of Bristol's total GHG footprint arising as a result of sectors such as production and manufacturing is significantly greater than their relative contribution to the GVA of the city. Distribution activities contribute fairly equally to both GHG emissions and Bristol's GVA. In contrast, sectors such as information, finance, real estate and professional services contribute much more (in relative terms) to Bristol's overall GVA than to the GHG footprint.

Further detail on the extent of emissions under each industry category can be found in the data tables accompanying this report.

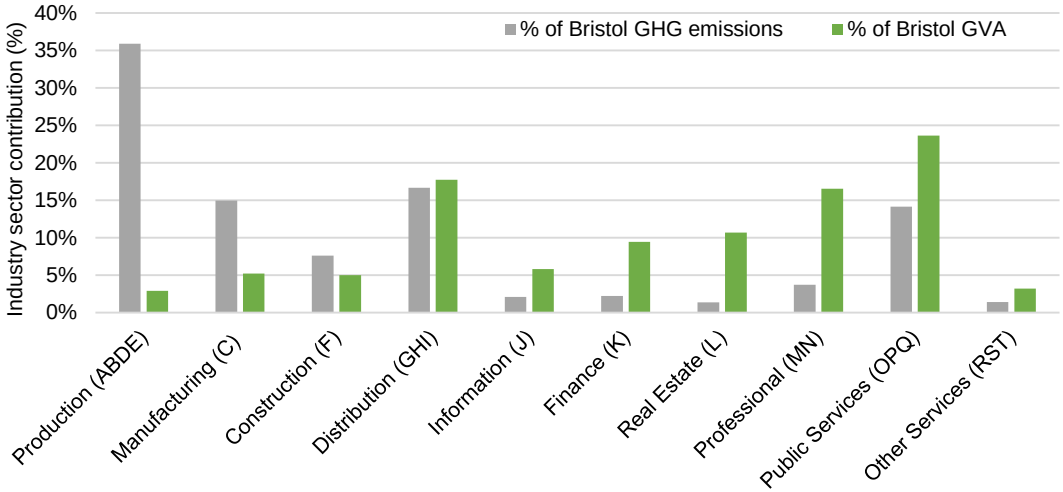

Figure 11: Contribution of industry sectors to Bristol's GHG footprint and GVA

29% of Bristol's total GHG footprint (82% of the 'production' footprint) is associated with the generation, transmission and distribution of gas and electricity in Bristol

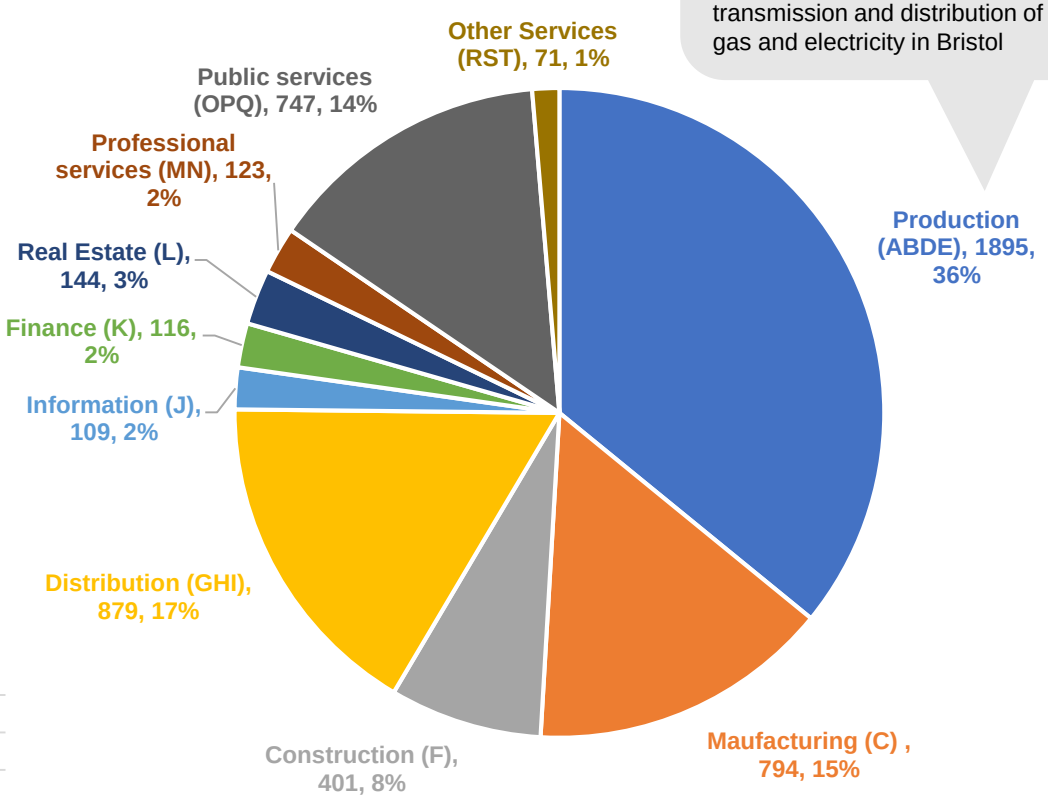

Figure 12: Bristol business GHG emissions (ktCO2e, % of total footprint) according to ONS industry sector

4. Results

C. Bristol business GHG emissions by industry sector (continued)

Production (SIC: A, B, D and E)

The 'production' footprint (reporting against activities such as mining, agriculture, power generation, water and wastewater services) accounts for the largest individual portion (36% or 1895ktCO_2e) of Bristol's overall GHG footprint.

As indicated in Figure 13, 82% of the 'production' footprint (29% of Bristol's total GHG footprint) is associated with power generation, transmission and distribution activities. Table 2 shows an extract of data from the spreadsheet accompanying this report, describing the emissions associated with power generated, distributed to and consumed by businesses in Bristol.

Direct (or territorial) emissions refer to those emitted within the city boundary either through direct use of fuel or in the production of goods and services that will also be consumed by businesses within the city. Consumption emissions refer to those expended outside of the Bristol City Council local authority for the production of goods and services consumed by businesses in Bristol *(C40 et al., 2018)*.

The direct GHG emissions associated with electric power generation, transmission and distribution within the city boundary are slightly higher than those associated with electric power consumed by businesses but generated and transmitted outside the city's geographic boundary. This is likely due to the methods of electric power generation within the city being more GHG intensive than those across the rest of the UK.

Power generation infrastructure in Bristol contributing to direct power generation emissions includes the Seabank Power Station (SSE and CK Infrastructure Holdings Ltd), Avonmouth Energy Recover Centre (Viridor) and four turbines at Avonmouth (Thrive Renewables). There is also a growing heat network in the City, owned and operated by Bristol City Council.

Manufacture and consumption of gas accounts for a much smaller proportion of Bristol's power generation footprint, with more GHG emissions associated with the consumption of gas produced outside of the city boundary.

Further detail on the extent of production emissions under each SIC sun-category can be found in the data tables accompanying this report.

Table 2: Data extract from Bristol's 'production' footprint describing power generation associated GHG emissions

SIC	Production (ABDE) sub category	Direct emissions (ktCO_2e)	Consumption emissions (ktCO_2e)
D35	Electric power generation, transmission and distribution	767	625
D35	Manufacture of gas; distribution of gaseous fuels through mains; steam and aircon supply	50	113

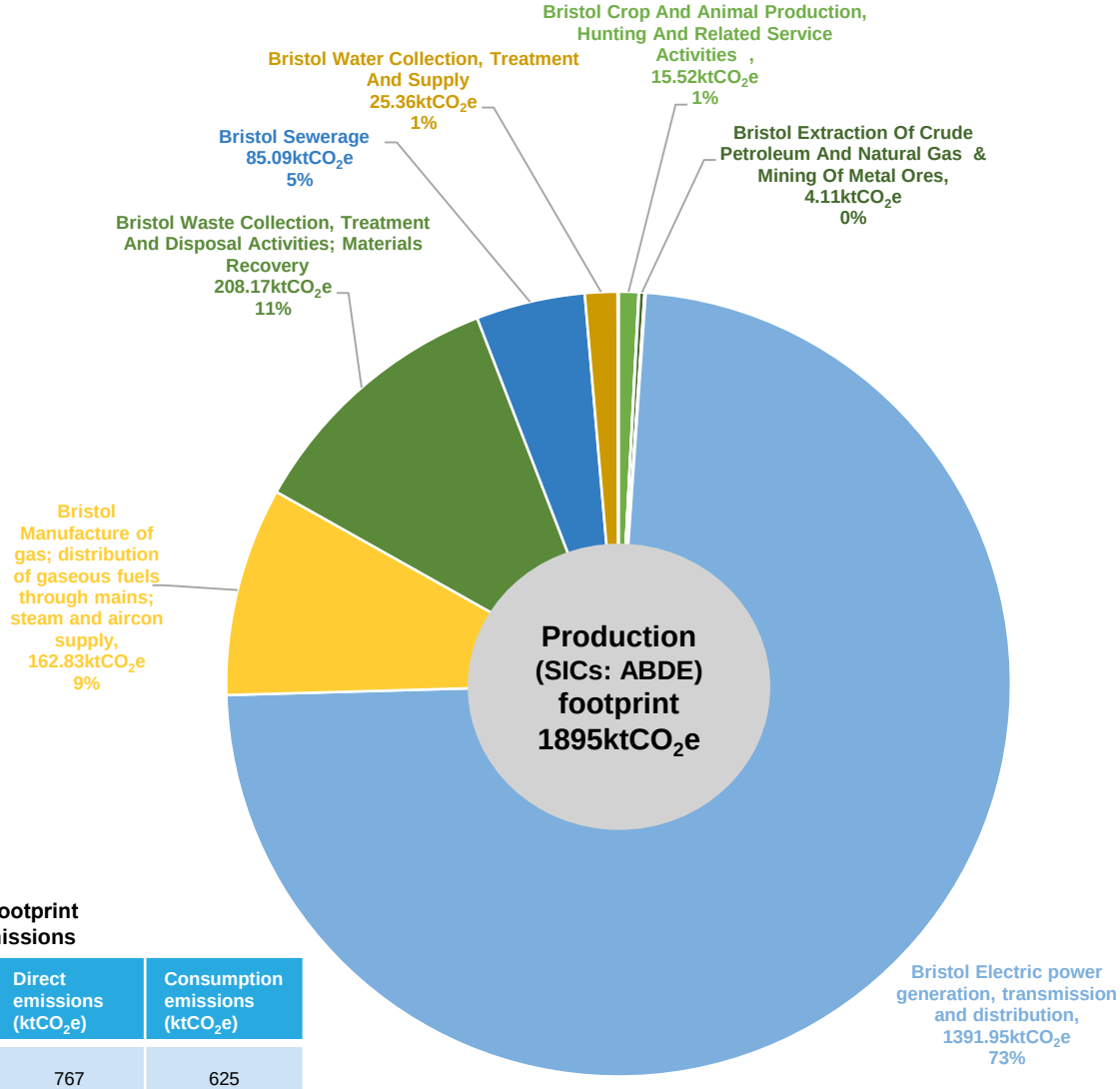

Figure 13: Bristol's production GHG footprint by SIC activity (ktCO2e, % of total footprint)

4. Results

C. Bristol business GHG emissions by industry sector (continued)

Distribution (SIC: G, H and I)

Distribution accounts for 17% (879ktCO$_2$e) of Bristol's total business footprint. This sector refers to emissions associated with wholesale and retail trade based activities, transportation of people and goods by all modes of transport, accommodation and food and beverage service activities. Figure 14 outlines the extent of distribution emissions by SIC sub-sector.

Transport of people and goods by air accounts for the largest portion (415ktCO$_2$e or 47%) of Bristol's distribution footprint. This reflects the international nature of Bristol business operations and supply chains.

Water transport accounts for 19% of Bristol's distribution related emissions. This includes all emissions associated with coastal freight and therefore reflects the shipping activities at the Bristol Port in Avonmouth.

The carbon footprint of air, water and land transport related activities presents a challenge for Bristol's businesses in reaching the city's net-zero 2030 target as low carbon travel must be integrated into operational and supply chain activities to reach the city's proposed emissions target.

Further detail on the scale of distribution emissions can be found in the dataset accompanying this report.

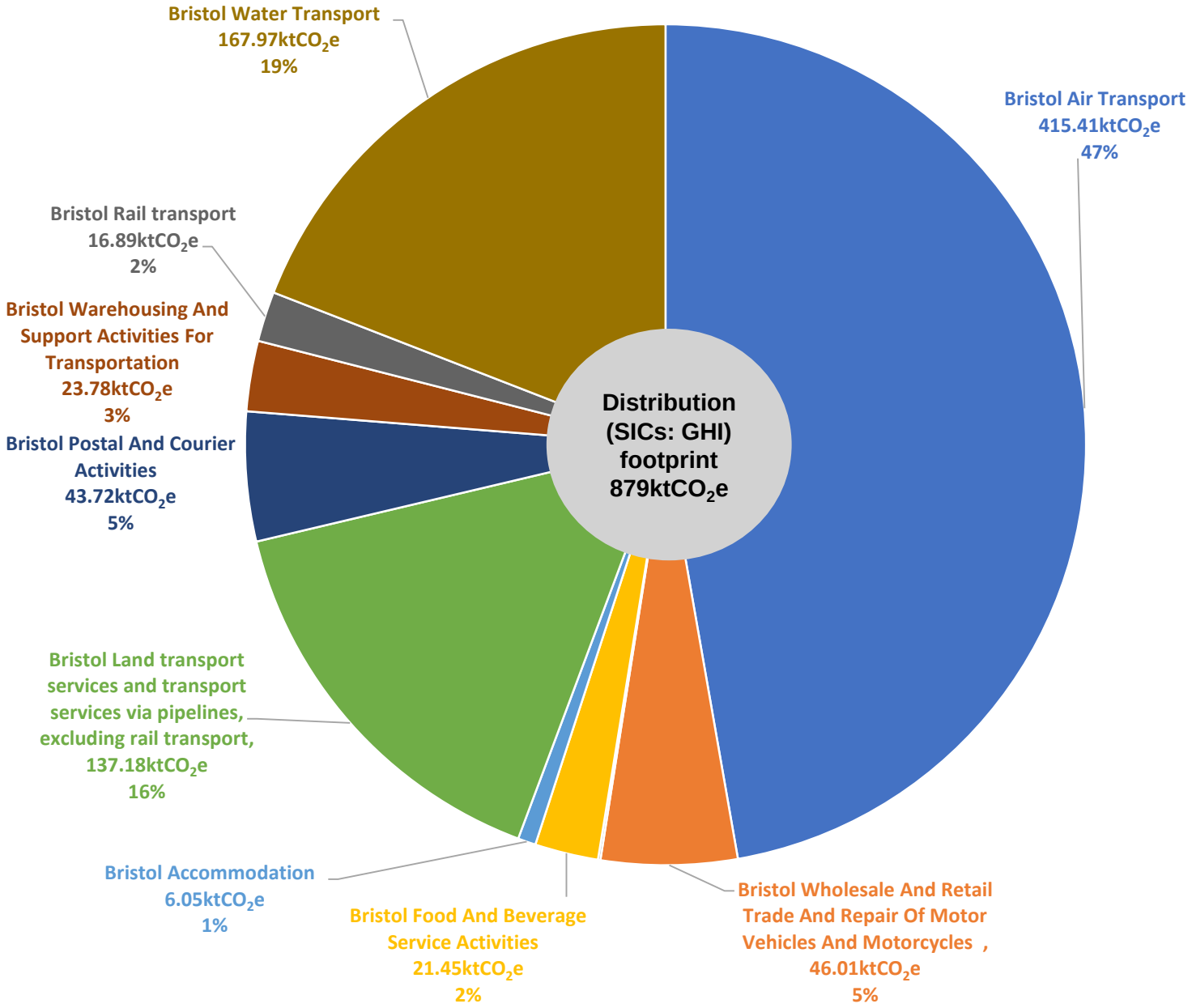

Figure 14: Bristol's distribution GHG footprint by SIC activity (ktCO2e, % of total footprint)

4. Results

C. Bristol business GHG emissions by industry sector (continued)

Manufacturing (SIC: C)

As shown in Figure 10, manufacturing accounts for 15% of Bristol's total business footprint. The manufacturing sector encompasses the manufacturing of food products, beverages, clothing, materials, chemicals, electrical equipment, machinery, vehicles and furniture *(ONS, 2009)*. Figure X shows the manufacturing activities that account for just over 50% of manufacturing emissions in Bristol while combining emissions associated with the remaining 38 SIC manufacturing activities in 'other manufacturing'. Other manufacturing accounts for the remaining emissions associated with the manufacturing and preparation of materials, chemicals and equipment both produced directly by Bristol-based businesses and procured from businesses outside of the city boundary. A complete list of the activities included in 'other manufacturing' can be found in the data spreadsheet accompanying this report.

The prevalence of food and drink service and retail businesses in Bristol is strongly reflected in the fact that five of the seven categories that account for 50% of Bristol's manufacturing emissions are associated with the production of food and drink products. This directly reflects the business and procurement activities of the 1,170 accommodation, food and beverage establishments in Bristol *(ONS, 2019)*. According to the top-down assessment of emissions conducted for this study, the manufacturing of alcoholic beverages and processing of meat products procured by businesses in Bristol are the activities with the highest associated emissions at 125.4ktCO$_2$e and 65.8ktCO$_2$e respectively. Manufacturing and preparation of fish, fruit, vegetables, dairy and grain-based products collectively account for 19% of the manufacturing footprint at 111.2ktCO$_2$e. Making up the final proportion of the top seven manufacturing categories, production of iron, steel and motor vehicles accounts for 12% (or 97.8ktCO$_2$e) of Bristol's manufacturing footprint.

Of Bristol's total manufacturing footprint, 70% is generated in manufacturing activities occurring outside the city boundary to create products procured by businesses within Bristol. To reach net zero 2030, this presents a challenged for Bristol businesses in establishing low carbon, sustainable and resilient supply chains.

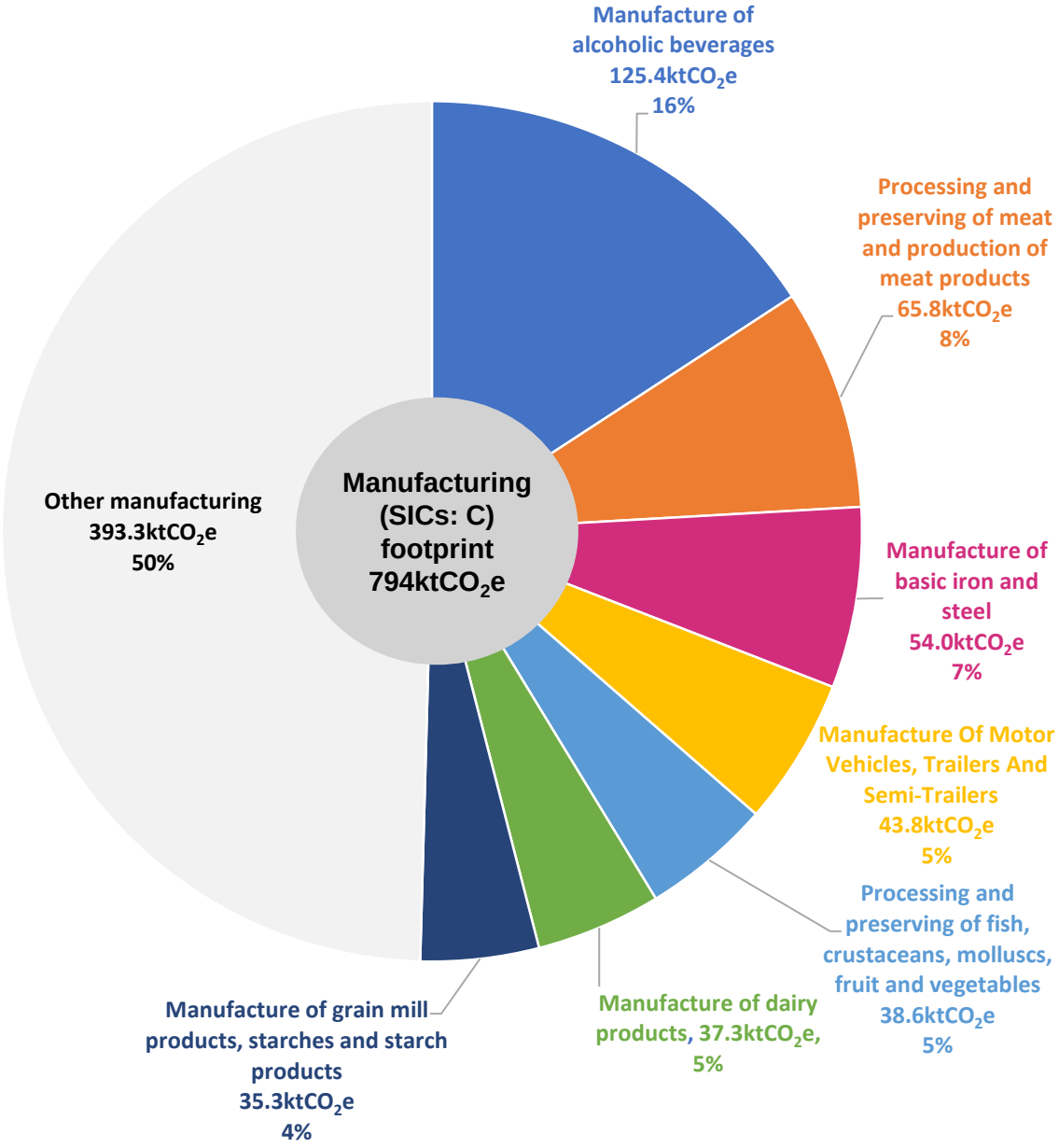

Figure 15: Bristol's manufacturing GHG footprint by SIC activity (ktCO2e, % of total footprint)

4. Results

C. Bristol business GHG emissions by industry sector (continued)

Public Services (SIC: O, P and Q)

Public service emissions include scope 1, 2 and 3 emissions related to public administration, defence, education, healthcare, residential care and social work activities. This industry sector accounts for 14% of Bristol's overall business and economy related emissions.

Accounting for the largest proportion of Bristol's public services delivery footprint is the provision of human health activities at 304.0ktCO$_2$e. This includes all hospital activities, medical and dental practice activities and all therapy and medical testing activities.

Public administration, defence and social security is the source of 251.9ktCO$_2$e emitted in the public services sector. This refers to general public administration activities conducted by local public bodies including research, tax collection and legislative administration. It also includes regulation of the activities of providing health care, education, cultural services and other social services. The provision of public education, residential care and social work activities collectively account for the remaining 25% of public services related emissions.

Given that public services are essential for the functioning of any urban area, organisations operating within this sector face a big challenge in the journey to net zero. Over the next 10 years, public services in Bristol must be adapted such that related emissions are reduced to zero, climate resilience is optimised and level of service is either maintained or improved to ensure equality in healthcare, education and security across the city.

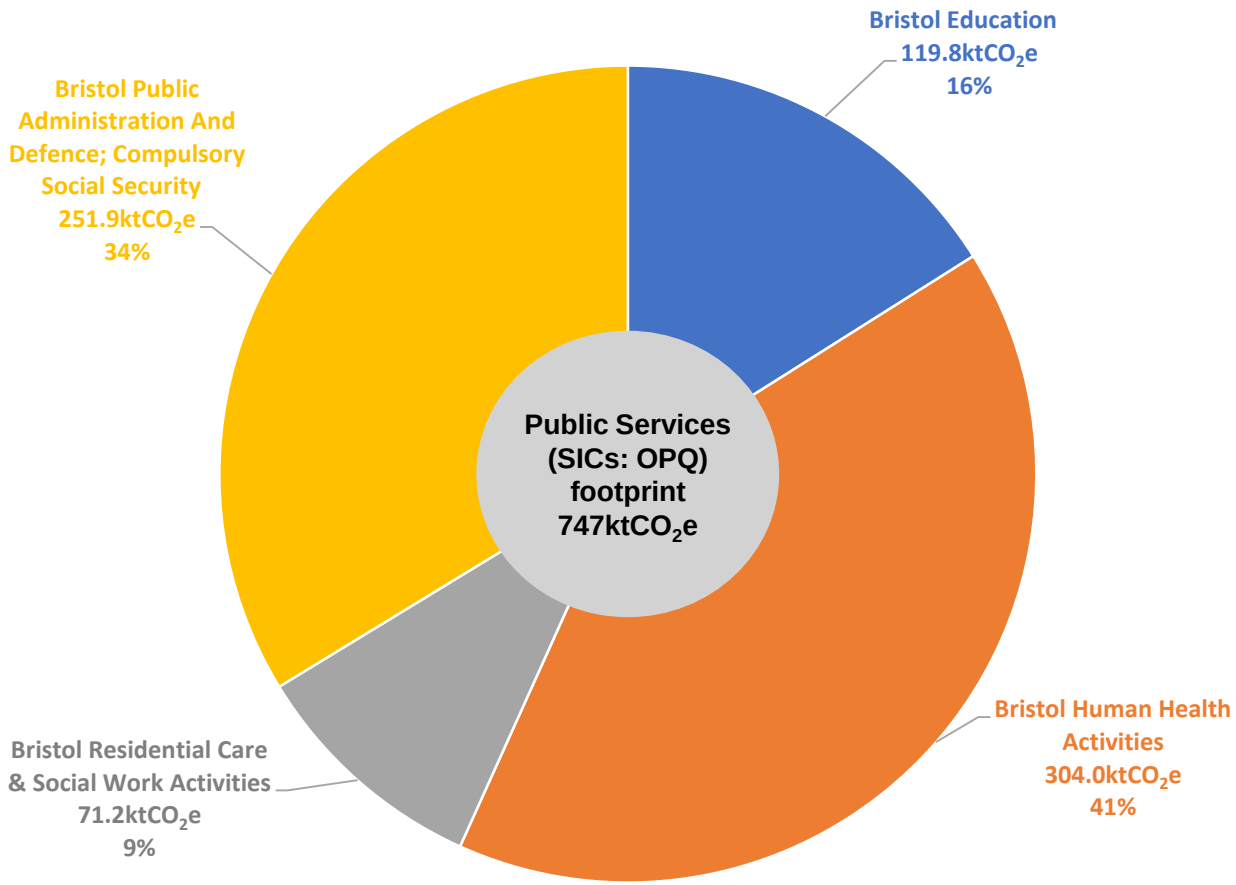

Figure 15: Bristol's public services GHG footprint by SIC activity (ktCO2e, % of total footprint)

5. Recommended next steps

Overview

The evidence base established in this report sets out the greenhouse gas emissions associated with business activities in Bristol according to a top-down analysis of ONS GVA data using the University of Leeds developed UK MRIO model. The evidence base is also accompanied by a set of sectoral case studies. For six sectors, the case studies provide industrial sector definitions, an overview of each sector's prominence in Bristol, climate change related risks and opportunities and a more detailed look at a Bristol-based company operating within each sector. The sectors addressed in the Bristol-based case studies are:

- Manufacturing
- Construction
- Distribution
- Information and communications
- Public services
- Professional services

Given the City of Bristol vision to be net-zero and climate resilient by 2030, the evidence base presented in this report and the findings from the sectoral case studies have been used to establish a set of immediate next steps for businesses in Bristol.

Conclusions

At 5,000ktCO_2e, the carbon footprint of Bristol's businesses and economy is significant. In particular, understanding that 50% of this footprint is from scope 3 emissions provides a different focus for businesses and organisations than has historically been the case.

The case studies provide us with an insight into some of the current efforts and challenges for individual businesses and of different sectors in reducing emissions to zero.

The results from this study represent a top down assessment, providing a sense of the relative magnitude of the challenge. There are some caveats and limitations to the use of these results (explained in section 7).

Reducing the emissions relating to Bristol's businesses and economy will require significant system change, including a significant shift in some of our historic business models.

It will be critical that such reductions support a fair transition, to continue to support a flourishing economy for Bristol.

Whilst the breakdown of emissions by sector is useful for analysis, we recognise the interdependencies between the footprint associated with Bristol's economy and that associated with households and individuals in the city. For example, stopping the manufacture of goods within the city might appear to support GHG reduction. However, this will not necessarily stop demand for the product from individuals and households in the city, and may result in higher emissions in aggregate. Consideration of the whole system will be required to support meaningful and GHG reduction.

The responsibility for supporting a routemap to carbon neutrality is shared across a range of partners in the city and beyond.

At 14%, the public services sector's footprint for the city is significant, and represents an excellent opportunity for the public sector to show leadership in reducing emissions, working with their supply chains.

Immediate next steps

It is beyond the scope of this study to set out a routemap carbon neutrality for Bristol's economy and business. However, recognising the size and scale of the challenge, we set out recommendations for immediate next steps. Whilst this study has been carried out on behalf of Bristol City Council, these recommendations are for the city as a whole, and identifying partners and the appropriate governance to support carbon reduction will be critical to create change. We recommend that Bristol should:

1. Develop communications plan for disseminating this evidence, sharing good practice, drivers for business change and exploring next steps with businesses, organisations and other important actors in the city's economy. This will support a shared understanding of the challenge and opportunity.
2. Establish bottom up footprints for some of the largest impact sectors (or key businesses and organisations within these sectors) identified within this study – Production, distribution, manufacturing, public services. This will support a greater understanding of the opportunities for carbon reduction in the areas with the biggest opportunities for change.
3. Work at sector-level to map largest carbon hotspots across business supply chains, to identify overlaps and opportunities for greatest reductions. This should identify opportunities for businesses and organisations to share resources in reducing emissions.
4. Undertake a study to consider the levers within the control of organisations within Bristol's boundaries, and consider where there might be a need for national level intervention to support Bristol's ambitions.

Public services should take a lead in all of the actions above; improving understanding (of scope 3 emissions, in particular), reducing emissions, and communicating successes and challenges.

6. Caveats and limitations

Caveats and limitations

The success and usefulness of studies that work to evaluate the extent of greenhouse gas emissions is fundamentally determined by the quality, completeness and reliability of data sources employed. As such this study is subject to two core limitations:

- Reliability of data sources used
- Complexity of reporting against emissions categories

The UK MRIO model used to support the data analysis in this study extracts data directly from the ONS produced National Accounts for the economic, emissions and energy extensions. This data undergoes many checks and revisions by the ONS but is not accompanied by any comment on the confidence intervals associated with data points. This means that the employed data is not unquestionably reliable. However, extracting data from an official and regulated UK source (the method used for this study) is significantly more accurate and reliable than using UK data from MRIO models where data has been manipulated to fit the particular model purpose.

The top-down modelling approach adopted in this study means that businesses in Bristol are evaluated using the same emissions intensities as average UK businesses for their supply chain. This means that the impact on the city's footprint of businesses in Bristol that draw on low carbon energy or material suppliers businesses may not be fully represented in this study. That level of granularity and detail may only be captured using a bottom-up approach. However, by using the GVA data local to geographic region, the scale of commercial activity is adjusted to reflect the regional specific context.

In the absence of Bristol-level data, the UK-level data set adopted for the purposes of this study represents the best available source. A large proportion of emissions assessed arise from the UK electricity grid, which is uniform across the UK.

The greenhouse gas protocol for cities indicates that emissions from sectors such as transport, agriculture, forestry and land use are particularly difficult to report accurately against *(GHGP, 2014).* Challenging data collection and allocation to emissions sectors and scopes places an inherent uncertainty on the accuracy of data used in this study.

As with any quantitative study, uncertainty of results can be impacted by the data modelling and analysis decisions taken by the delivery team. To mitigate against these uncertainties, the methodology, approach, data analysis techniques and results employed and established through this study have been reviewed by experienced specialists, including the University of Leeds team who developed the MRIO model.

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