

1 **Waste management in SMEs – a barrier to developing circular cities**

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8
9 **Abstract**

10 The Commercial and Industrial (C&I) waste stream is complex due to the diversity of waste
11 generated and the variation in types of businesses by type and size. In England more waste
12 is generated by businesses than households but despite this the C&I waste stream has
13 historically been overlooked in waste policy with many businesses, in particular SMEs, not
14 recycling leading to resources being wasted. A key component of developing circular cities is
15 implementing *smarter* systems for managing waste from SMEs. In England the government
16 has pledged to improve the management of waste from businesses– however it is uncertain
17 what interventions, if any, it will make. This paper evaluates the policy towards recycling for
18 SMEs in 42 cities and models the impact such interventions could have on SMEs in England
19 based on waste data collected from 62 SMEs. The results highlight the patchwork of policies
20 globally regarding the C&I waste stream with 27 of cities evaluated having no requirement
21 for businesses to recycle at all. In cities where business recycling was mandatory the policy
22 varied from being fully mandated to having exemptions based on the type and size of
23 business, and the levels of waste generated. From the recycling policies identified seven

24 scenarios were modelled to assess what impact these interventions could have in England.
25 Mandatory separation of dry recycling and biowaste for all SMEs would have the biggest
26 impact leading to 55% additional waste being separated – totalling 1,529 kg per week from
27 the 62 SMEs sampled.

28

29 **Keywords**

30 commercial & industrial waste; circular economy; SMEs; waste policy; recycling; circular cities.

31 **1. Introduction**

32 ***1.1 Commercial and Industrial waste***

33 Numerous studies have stated it is hard to compare waste management practice globally
34 due to varying definitions of waste streams and different management strategies being
35 adopted (Chalmin and Gaillochet, 2009; Eunomia, 2017; Greene and Tonjes, 2014;
36 Greenfield and Woodard, 2016; Kaza et al, 2018; Policy Exchange, 2017; Resource Recovery
37 Forum and David Davies Associates, 2004; United Nations Environment Programme, 2010).
38 As highlighted by the United Nations Environment Programme (2015) these distinctions
39 become even more complex in Less Economically Developed Countries (LEDCs) due to waste
40 streams being merged, and the paucity of reliable data (). A key area where there is a lack of
41 consistency is the management of Commercial and Industrial waste, hereafter referred to as
42 C&I waste or business waste.

43 The C&I waste stream is complex with materials ranging from those similar in composition
44 to household waste through to specialist chemicals and composite products. The waste is
45 generated from single employee enterprises through to multinational businesses. As shown

46 in Table 1 the definition of municipal waste varies throughout the world with nations
 47 including C&I waste partially or fully within the definition of municipal waste, whereas in
 48 others it is categorised separately. There is also variation in how C&I is managed – in some
 49 countries it is fully or partially managed with household waste, whereas in others it is
 50 collected and managed separately. Variables for the inclusion of C&I waste within municipal
 51 waste include the size of the business generating the waste and the composition of the
 52 waste.

53

54 **Table 1 Global comparison of how C&I waste is integrated into the municipal waste**
 55 **definition**

Area	Inclusion of C&I waste within the definition of municipal waste	Sources
Europe	<p data-bbox="344 1128 1038 1279">Some countries include only household waste in their definition of municipal waste whereas others include elements of C&I, hazardous and construction waste.</p> <p data-bbox="344 1361 1107 1861">The European Union (EU) define municipal waste as <i>“waste from households and waste from other sources, such as retail, administration, education, health services, accommodation and food services, and other services and activities which is similar in nature and composition to waste from households...Member states are to ensure that waste from large commerce and industry which is not similar to waste from households is not included in the scope of municipal waste”</i> (Council Directive, 2018/851).</p>	<p data-bbox="1145 1128 1374 1451">European Environment Agency, 2013; Green Alliance, 2009; Wilson et al. 2001.</p> <p data-bbox="1145 1655 1374 1742">Council Directive, 2018/851.</p>

Pan America	Municipal waste includes solid or semi solid waste generated in population centres including domestic and commercial wastes as well as those originated by small scale industries and institutions (including hospitals and clinics), markets, street sweepings and from public cleansing.	Hoornweg and Bhada-Tata, 2012
USA	Municipal waste includes residential waste and waste from commercial and institutional locations such as businesses, restaurants, schools and hospitals. It does not include other types of waste including automobile bodies, sludges, combustion ash, construction and demolition, and industrial process waste.	United States Environmental Protection Agency, 2013
Canada	Waste is defined as residential and non-residential – not municipal. Classifies commercial, industrial and waste from institutional facilities such as schools and hospitals together as non-residential.	Statistics Canada, 2010
Asia	In India, Republic of Korea, Taiwan and Japan municipal waste includes part of the waste from industrial sources depending on waste types. In Hong Kong industrial waste is officially included in municipal waste.	Terazono et al., 2005

56

57 Based on data from the Organisation for Economic Co-operation and Development (OECD)
58 24% of waste generated by member nations is household waste or municipal waste (and
59 therefore would contain some C&I waste) compared to 33% C&I waste (United Nations
60 Environment Programme, 2015). Research from Frost & Sullivan (2011) estimated that the
61 value of the European C&I waste market was US\$75 billion in 2010 and would grow by more

62 than 1% per year to 2017 due to increasing waste levels and investment in new services.

63 More recent research suggests that the global commercial waste market stood at US\$141

64 billion in 2018 with a compound annual growth rate of 6.7% (Adroit Market Research,

65 2020). Despite the importance of C&I in terms of waste levels and market size, global waste

66 policy has generally overlooked C&I waste focusing on municipal and household waste. At

67 European Union (EU) level the Landfill Directive 1999 (Council Directive 1999/31/EC) and

68 Waste Framework Directive 2008 (Council Directive 2008/98/EC) set targets based on

69 municipal waste and household waste respectively with no corresponding targets

70 specifically for C&I waste. The European Federation of Waste Management and

71 Environmental Services have lobbied for more inclusion of C&I waste in future European

72 waste policy thereby improving resource efficiency and filling the policy gap (European

73 Federation of Waste Management and Environmental Services, 2017). In the UK waste

74 industry bodies have also argued for closer integration of these waste streams helping to

75 develop more economic and resource efficient management systems (Environmental

76 Services Association, 2016). In May 2018 new incremental targets were agreed in the EU

77 Circular Economy Package for recycling of municipal waste up to 65% in 2035 (Council

78 Directive, 2018/851). As per the EU definition of municipal waste (see Table 1) the targets

79 integrate some C&I waste if it is similar in composition to waste deriving from households,

80 but there remain uncertainties how these levels will be equated, and progress measured

81 given the complexities of the definition and inconsistencies in data across member states.

82 Significant quantities of C&I waste will still be excluded and within English waste policy

83 there are no holistic targets at all for C&I waste with targets set out in the most recent

84 Waste Strategy transposing those set out in the Circular Economy Package (Department for

85 Environment, Food and Rural Affairs, 2018). Ricardo Energy & Environment (2016) suggest

86 that the lack of reliable data on the quantity, composition and management of C&I waste
 87 both in the EU and UK maybe a reason why specific targets have not been introduced.

88 **1.2. Management of C&I waste in England**

89 The full definition of C&I waste in England is set out in section 75 of the Environmental
 90 Protection Act 1990 (see Table 2) - it is all waste generated by industry and commerce. In
 91 England local authorities are responsible for managing household waste and there is a
 92 mandatory requirement for them to submit data to central government on how this waste is
 93 being managed. No such system exists for C&I waste resulting uncertainties on the levels of
 94 waste generated and how it is managed.

Waste stream	Definition	Tonnes generated 2017 (million tonnes)
Commercial	Waste from: premises (including agriculture) used wholly or mainly for the purposes of a trade or business or the purposes of sport, recreation or entertainment excluding household waste or industrial waste. Waste from:	27.1
Industrial	-any factory; -any premises used for the purposes of, or in connection with, the provision to the public of transport services by land, water or air; -any premises used for the purposes of, or in connection with, the supply to the public of gas, water or electricity or the provision of sewerage services;	10.8

-any premises used for the purposes of, or in connection with, the provision to the public of postal or telecommunications services; or any mine or quarry.

95 **Table 2 Definition, arisings and management of Commercial and Industrial Waste in**

96 **England** (Adapted from Department for Environment, Food and Rural Affairs & Government
97 Statistical Service, 2019; Great Britain, 1990)

98 For example, the government estimated that in 2012 38.9 million tonnes of C&I waste was
99 generated (Department for Environment, Food and Rural Affairs and Government Statistical
100 Service, 2016) but this estimate was “*revised substantially*” by the government with 2014
101 data suggesting waste levels had reduced to 19.8 million tonnes – a 65% reduction
102 (Department for Environment, Food and Rural Affairs, 2017). This significant change was
103 due to adjustments in the methodology adopted by the government rather than actual
104 changes in the quantities of waste generated and its management, and there continues to
105 be a debate surrounding the quality of C&I data and our understanding of the waste stream.
106 A further complication is that historically in England, unlike some other EU member states,
107 elements of the C&I stream have not been included in the definition of municipal waste – to
108 address this the government has a reconciliation project which attempts to develop more
109 reliable data on the waste stream (see Department for Environment, Food and Rural Affairs
110 and Government Statistical Service, 2018). The latest government estimate is that 37.9
111 million tonnes of C&I was waste generated in 2017 far exceeding the 22.4 million tonnes
112 produced from households (Department for Environment, Food and Rural Affairs and
113 Government Statistical Service, 2019). The most recent data showing the breakdown of C&I
114 waste by source was published in 2011 with 30.7 million tonnes being generated in England

115 by Small and Medium Enterprises (hereafter referred to as SMEs) in 2009, 64.4% of the total
116 C&I waste generated (Jacobs, 2011). SMEs are defined by the European Commission (2005)
117 as businesses with less than 250 employees or have a turnover of less than €50 million.
118 SMEs represent more than 90% of global businesses and account, on average, for about 50%
119 of Gross Domestic Product of all countries and for 63% of their employment (Association of
120 Chartered Certified Accountants, 2010). As such SMEs have a significant impact on resource
121 flows and the implementation of the Circular Economy model.

122 In England individual businesses choose how their waste is collected but they have a legal
123 obligation to ensure that the waste they generate is managed responsibly. The
124 Environmental Protection Act 1990 places a Duty of Care on all businesses to ensure that
125 any controlled waste produced as part of their business or within their workplace is handled
126 safely and within the law (Great Britain, 1990). Businesses typically enter contracts with
127 public sector or private service providers for the collection of waste and recycling – however
128 as highlighted by Woodard (2020) many SMEs still illegally dispose of their waste through
129 household waste services which is prohibited under Duty of Care. In addition, there are a
130 range of regulations that stipulate businesses should recycle. Under the Landfill Directive
131 waste should be treated before going to landfill. Under the Directive treatment includes
132 *“physical, thermal, chemical or biological processes including sorting that changes the*
133 *characteristics of the waste in order to reduce its volume or hazardous nature, facilitate its*
134 *handling or enhance recovery”* (Council Directive 1999/31/EC) thereby separating out
135 recycling would be counted as treatment. Under amendments to the Waste (England and
136 Wales) Regulations introduced in September 2011 businesses that generate waste are
137 required to apply all possible measures to implement the waste hierarchy (which would

138 include recycling) and there is a requirement to include a declaration that the waste
139 hierarchy has been adhered to on Waste Transfer Notes which are issued when waste is
140 being collected. Amendments to the Waste Framework Directive mean that waste collectors
141 must separately collect paper, plastic, metal, and glass (Council Directive 2008/98/EC). This
142 is transposed in England through Section 13 of the Waste (England and Wales) Regulations
143 (2011) that stipulate that an establishment that collects waste must collect waste paper,
144 metal, plastic, and glass separately from the 1st of January 2015 if technically,
145 environmentally and economically practicable (TEEP). Public and private waste service
146 providers must judge for themselves whether separate waste streams are required against
147 TEEP, and revisit this regularly (HM Government, 2011). Proof and evidence of the analysis
148 must be stored to present to the Environment Agency, the regulatory body, if requested
149 (Gov.uk, 2014). For clarity, comingled recycling which is then separated at a Materials
150 Recycling Facility is classified as a form of separate collection. The interesting point here is
151 that the regulations place responsibility on the collector of the waste rather than the
152 producer.

153 Despite these requirements there has been little to no enforcement of these regulations
154 and research has shown that many businesses, particularly SMEs still do not recycle and
155 there is discrepancy between large and small SMEs. GHK (2010) showed that 67% of SMEs
156 recycled but the propensity to recycle increased with business size; 44% of sole traders did
157 not recycle compared to 6% of SMEs with over 100 employees. The Federation of Small
158 Businesses has lobbied government to improve the waste services for SMEs and arguing this
159 would improve compliance levels with Duty of Care (Federation of Small Businesses, 2011).
160 In the 2011 Review of Waste Policy in England the government stated that they would be

161 taking steps to improve the waste and recycling services to businesses especially SMEs
162 (Department for Environment, Food and Rural Affairs, 2011a). A range of actions were
163 implemented including good practice commitments that public and private sector service
164 providers could sign up to improve services to SMEs (DEFRA, 2011b), guides to help
165 providers improve services (Waste Resources Action Programme, 2011, 2012b, 2013a);
166 service providers charging less for recycling than residual waste (Waste Resources Action
167 Programme, 2013b) and the use of Business Improvement Districts¹ (BIDs) to incentivise
168 businesses to use the same contractor for recycling and waste therefore improving
169 efficiencies (Roberts, 2012).

170 Despite these actions the government estimate that recycling rates in businesses generating
171 municipal waste remain at only 35% (Department for Environment, Food and Rural Affairs,
172 2019a) and there continues to be high levels of non-compliance with Duty of Care with 46%
173 of businesses not knowing what happens to their waste once it leaves site (Right Waste,
174 Right Place, 2017). In evidence submitted to the House of Commons Environment Select
175 Committee (2014) in 2014 the Chartered Institution of Waste Management (CIWM)
176 highlighted the total withdrawal from policy and intervention on C&I waste by government.

177 In the government's most recent waste strategy 'Our Waste, Our Resources' (Department
178 for Environment, Food and Rural Affairs, 2018) the government once again acknowledged
179 that more needed to be done to support businesses to recycle. In July 2019 the government
180 published the results of consultation on proposals to increase recycling in businesses –
181 though its important to note that the consultation focused on waste from businesses which

¹ BIDS are a defined area in which businesses are required to pay an additional levy to fund projects within the district's boundaries.

182 is similar in nature and composition to household waste – and as such does not include all
183 businesses. 95% of respondents to the consultation agreed that businesses should be legally
184 required to separate out dry recycling – with similar support for the requirement for
185 businesses to separate food waste. Of a series of options set out in the consultation the
186 preferred collection option based on responses was businesses being required to separate
187 out mixed dry recycling (paper, card, plastic bottles, metals), and glass and food waste for
188 collection – and the majority of respondents stated there should be no exemptions – it
189 should be fully mandatory (Department for Environment, Food and Rural Affairs, 2019b).
190 The government subsequently announced they would to amend legislation so that
191 businesses must make arrangements to separate recyclable waste from residual waste, and
192 the government would consider other interventions to support small and micro businesses
193 (Department for Environment, Food and Rural Affairs, 2019c). However, it is unclear when
194 the legislation will be revised or how it will be enforced, and what other interventions they
195 will make.

196 ***1.3. Aim and objectives***

197 Whilst there have been considerable peer reviewed papers on the household waste stream
198 there remains limited research to understand SME waste including the composition of the
199 waste, and current management behaviour. Similarly, there is limited research looking at
200 the policy instruments and mechanisms that have been adopted globally to support
201 recycling within SMEs. If England is to adopt the principles of the Circular Economy to
202 support the development of circular cities, a basic building block will be ensuring that
203 recyclables and biowaste are being collected from businesses. At present there is clear

204 leakage of resources from the C&I waste stream from businesses not recycling and that
205 England lacks the relevant policy and vision to address this problem.

206 This paper assesses the impact that policy on business recycling from other jurisdictions,
207 and current government proposals requiring businesses to recycle, could have on resource
208 flows for SMEs in England. The aims were to (i) Evaluate the policy and approaches towards
209 managing C&I waste in a sample of global cities with a focus on the requirement for
210 mandatory recycling and separation of biowaste (organics); (ii) Undertake residual waste
211 composition analysis for a sample of SMEs to understand the waste levels and composition
212 from these businesses and to evaluate current resource leakage of recycling and biowaste;
213 (iii) Apply scenarios based on the identified policies from evaluated cities and the
214 government's proposals, to assess the impact on resource flows; (iv) Make
215 recommendations for the improvement of recycling services for SMEs in England.

216 The research was conducted in two stages. Stage 1 evaluated the approach towards
217 managing C&I waste in 42 global cities. The European Commission commissioned BiPRO &
218 CRI (2015) to understand how waste source separation schemes operate in European capital
219 cities including the provision of C&I waste. To avoid duplication this study focuses on 42
220 cities in USA, Canada, Australia and New Zealand. In stage 2 residual waste was collected
221 from 62 SMEs for analysis to understand the composition and levels of waste being
222 generated. Scenarios developed based on the identified policies on recycling from stage 1,
223 plus government proposals, were then applied to the 62 SMEs to evaluate the impact on
224 their requirement to recycle or segregate biowaste. The methodology applied is presented
225 in section 2, results and discussion of the policy evaluation in section 3, results and
226 discussion of the waste composition and modelling in section 4.

227 **2. Materials and methods**

228 ***2.1 Stage 1 – Evaluation of international policies on SME recycling***

229 The evaluation consisted of collating and appraising legislation, policy documents and online
230 resources from the 30 most populous cities in the USA (covering 21 states), and the 4 most
231 populous cities in Australia, Canada, and New Zealand making 42 cities in total. Studies have
232 already looked at approaches in other European cities and therefore the geographical scope
233 was widened. Moreover, some innovative approaches towards waste have been developed
234 in these territories, for example bans on waste to landfill and mandatory recycling of some
235 products (Northeast Recycling Council, 2017) and deposit schemes on beverage containers
236 (Eunomia, 2015), therefore it was interesting to understand their approach towards C&I
237 waste. Within these countries there is also more autonomy within the governance system to
238 introduce localised waste policy – for example in the USA there is scope for state, county,
239 district or city ordinances and regulations. Therefore, a variation of approaches may be
240 adopted – this is unlike in England where waste policy is developed by central government.
241 Finally, due to the complexities regarding regulations it was decided to focus on English
242 speaking nations enabling reliable access to information and interpretation. The evaluation
243 focused on (i) if separation of dry recycling and/or biowaste was mandatory for businesses (ii)
244 if so, how the policy was implemented. Whilst in Europe the term ‘biowaste’ is used, in the
245 cities evaluated ‘organics’ was commonly referred to in policy – throughout the paper these
246 terms are interchangeable.

247

248

249 **2.2 - Waste generation and composition from SMEs**

250 Data was collected on the levels and composition of waste from 62 different SMEs in
251 Brighton and Hove City - the aim was to include businesses from a range of sectors and all
252 the waste sampled was being disposed of in the residual stream and not being recycled.

253 All participants were recruited by invites submitted through business networks in the City or
254 cold calling. On recruitment an interview was arranged at a time appropriate for the SME to
255 explain the project and a record made of their Standard Industrial Classification (SIC) code²,
256 number of employees and notes made on their current waste management activity. 51
257 businesses in the study were micro businesses with less than 5 employees and 11 were
258 small businesses - with 25 being the most employees.

259 For 38 businesses all waste that they generated was taken for analysis – they did not have a
260 contractor in place at all for recycling. For an additional 9 businesses all waste was taken
261 apart from specialist waste streams they produced such as chemicals, hazardous waste or
262 used cooking oil that would be collected by specialist contractors. For the remaining 15
263 businesses all waste was collected apart for recycling that was already being collected by a
264 contractor (11 had a multi-material collection, 2 for glass only and 2 for cardboard). The
265 focus on the research was to understand the residual waste stream and material losses and
266 what impact new policy interventions could have.

² A SIC code is used to describe activity to business is engaged in and all businesses are required to provide a SIC code when submitting paperwork to Companies House who keep official records of businesses in the UK. SIC originates from the USA in 1937 and has been used in the UK since 1948.

267 For all businesses a weeks' worth of residual waste was taken for analysis. The waste for
268 each business was systematically sorted into categories based upon European Waste Codes
269 and weighed. Note the sample size was restricted due to the logistics of collecting waste
270 from businesses and the limited time available at the facility where waste was analysed. All
271 data was collected in confidence and analysed anonymously with researchers complying
272 with Data Protection Act guidelines.

273 **3. Stage 1 - Evaluation of international policies on SME recycling**

274 **3.1 – Results**

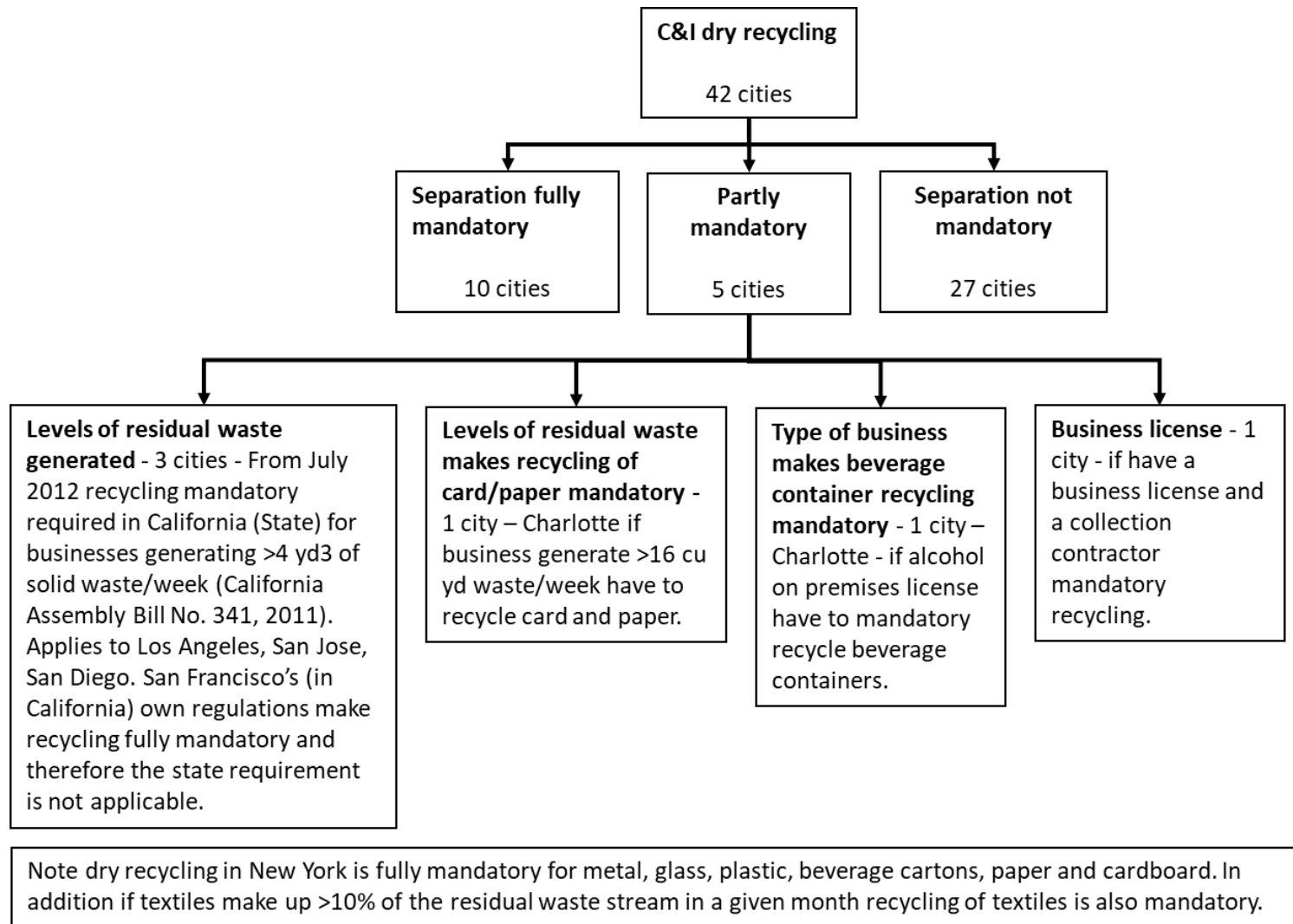
275 In 27 of the 42 cities there was no requirement for businesses to recycle at all. Conversely it
276 was mandatory for businesses to recycle in 15 cities and for biowaste waste to be separated
277 in 12. There was variation in the scope of these regulations ranging from all businesses
278 being required to recycle and separate biowaste through to conditions and exemptions.
279 Recycling of dry recyclables was fully mandated in 10 cities and biowaste in 3 cities (plus
280 another for yard waste only). Table 3 provides a summary of the mandatory policies within
281 the 15 cities including the governance level at which the requirement is mandated (i.e.
282 state, city, county, district). Fully mandatory means all businesses need to comply with the
283 regulations. Partly means there are conditions relating to compliance – for example the
284 requirement to recycle only applies to certain businesses or materials. Figures 1 and 2
285 provide further detail with full information are set out in in Appendix A (see e-component).

286 **Table 3 Overview of mandatory requirement for businesses to recycle and separate out biowaste in the cities analysed**

City (state)	Governance level of regulation	Mandatory Dry recycling	Mandatory Biowaste	Regulation
Los Angeles (California)	State	Partly	Partly	California Assembly Bill No. 341 (2011) California Assembly Bill No. 1826, Chapter 727 (2014)
San Jose (California)	State	Partly	Partly	See Los Angeles
San Diego (California)	City – dry recycling	Fully	Partly	San Diego Municipal Code – Division 7 Recycling Ordinance (2007)
	State - biowaste			California Assembly Bill No. 1826, Chapter 727 (2014)
San Francisco (California)	City – note made mandatory in 2009 before state regulations	Fully	Fully	San Francisco Mandatory Recycling & Composting Ordinance 100-09 (2009)
Washington (District of Columbia)	District	Fully	✘	DC Solid Waste Management and Multi- Material Recycling Act of 1988 and updated in 2010

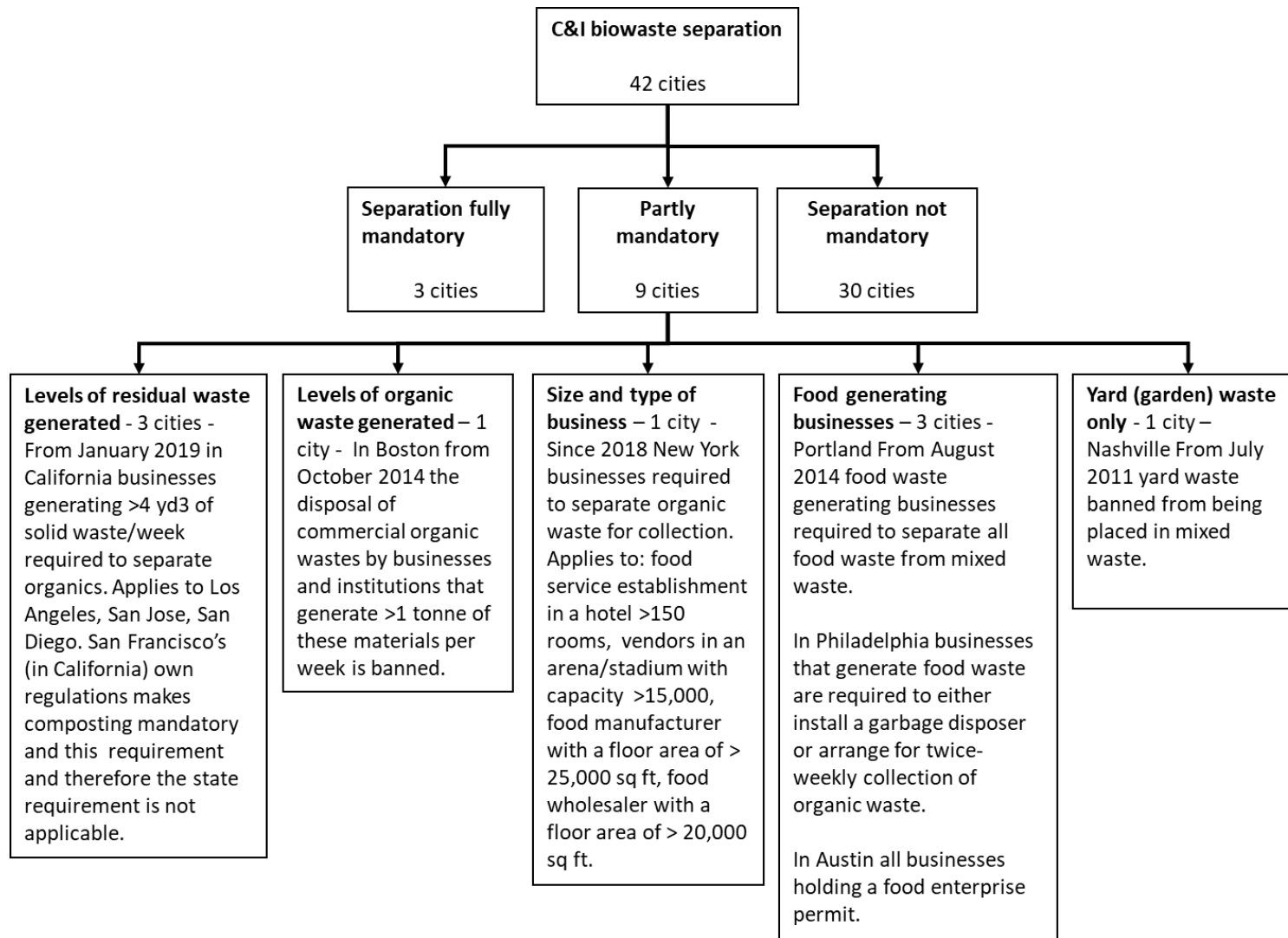
City (state)	Governance level of regulation	Mandatory Dry recycling	Mandatory Biowaste	Regulation
Chicago (Illinois)	City	Partly	✘	Latest iteration (2016) of City of Chicago Residential and Commercial Recycling Ordinance
Boston (Massachusetts)	State	Fully	Partly	Massachusetts Department of Environmental Protection (2014) 310 CMR 19.000
New York City (New York)	City	Fully	Partly	Local Law 87 of 1992 – latest iteration through Local Law 2020/015
Charlotte (North Carolina)	County/State	Partly	✘	Mecklenburg County Source Separation Ordinance/General Assembly Of North Carolina 2005 session Law 2005-348 House Bill 1518
Portland (Oregon)	City	Fully	Partly	Latest iteration of Business Recycling Requirements, (1) and (2).
Philadelphia (Pennsylvania)	State/City – dry recycling City - biowaste	Fully	Partly	Pennsylvania Act 101 Chapter 10-722 of the Philadelphia Code

City (state)	Governance level of regulation	Mandatory Dry recycling	Mandatory Biowaste	Regulation
Nashville (Tennessee)	City	Partly	Partly	Nashville Solid Waste Code (2010)
Austin (Texas)	City	Fully	Partly	Latest iteration Austin, Texas - Code of Ordinances - 15-6-91 recycling
Seattle (Washington)	City	Fully	Fully	Latest iteration Seattle Municipal Code sections 21.36.082 and 21.36.083 – <i>though some exemptions based on storage</i>
Calgary	City	Fully	Fully	City of Calgary Commercial Waste Recycling Bylaw



288

289 **Figure 1 Conditions of the requirement to separate dry recycling where it is partly mandatory**



290

291 **Figure 2 Conditions of the requirement to separate biowaste where it is partly mandatory**

292 **3.2 Discussion**

293 The results highlight the variation in practice towards the management of the C&I stream.
294 Across the 42 cities evaluated in 27 cities (64%) there was no requirement for businesses to
295 recycle with no cities in Australia or New Zealand having this requirement. In the cities
296 where recycling was mandated there was variation in these how the regulations were
297 applied (see Figures 1 and 2). In the USA whilst some states have laws requiring mandatory
298 recycling or the separation of organics, some cities and counties have their own stricter
299 regulations or ordinances predating those at state level. For examples in California under
300 (California Assembly Bill No. 341 (2011) since July 2012 recycling has been mandatory for
301 businesses that create four yd³ (3,058 litres)³ or more of solid waste per week. However, in
302 San Francisco (in California) mandatory source separation of recycling, organics and residual
303 waste for businesses was introduced 3 years earlier in 2009 under the San Francisco
304 Mandatory Recycling & Composting Ordinance 100-09 (2009). Some of the cities have had
305 policies on business recycling for almost 30 years – for example as stipulated in Local Law 87
306 since 1992 businesses in New York have been required to recycle and the requirement
307 coming fully mandatory in 2016.

308 Recycling of dry recyclables was fully mandated in 10 cities with businesses typically
309 required to recycle plastic and glass bottles and jars, paper, metal containers, and
310 cardboard. However, within the other cities a range of variables were identified which
311 dictated if businesses had to recycle (see Figure 1) or separate biowaste (see Figure 2).
312 These are considered below.

³ 1 yd³ = 764 litres

313 **Levels of residual waste** – In California the levels of waste generated by a business dictated
314 if separation of recycling or biowaste was mandatory. As mentioned previously recycling has
315 been mandatory for businesses that have the capacity to create 4 yd³ or more of solid waste
316 per week and since January 2019 businesses generating this level of waste have also been
317 required to separate and pay to have organics collected. By the end of 2021 if disposal of
318 overall of organic waste in the state has not reduced to 50% of the level in 2014 this
319 requirement reduces to businesses generating over 2 yd³per week (California Assembly Bill
320 No. 1826, Chapter 727, 2014). To help businesses understand if they would be within the
321 thresholds for mandated separate collection a Generator ID tool was developed providing
322 profiles of different business types and projected levels of organic waste (Calrecycle, 2017).
323 Jurisdictions in California are also required to conduct outreach programmes to inform
324 businesses how to recycle organic waste, and conduct monitoring to identify those not
325 recycling and inform them of the law and how to recycle organic waste. In Charlotte under
326 the Mecklenburg County Ordinance (2006) businesses generating over 16 yd³ of waste per
327 week are mandatory required to recycle paper and cardboard.

328 **Levels of specific material in the waste stream** – In Boston (Massachusetts) businesses
329 generating over a tonne of food waste per week are mandatory required to segregate food
330 (Massachusetts Department of Environmental Protection, 2014). In New York if waste is
331 made up of over 10%-yard (garden) waste within a month, businesses have been required
332 to recycle it (the same applies to textiles). In Portland a more arbitrary approach is used
333 where the Bureau of Planning & Sustainability determine which businesses need to separate
334 food waste based on levels.

335 **Combination of size and types of business** – In New York City a combination of size and
336 type of business influenced if it was mandatory to separate food waste. In New York
337 regulations have been rolled out through Local Law 2013/146 based on industry and size
338 requiring businesses to separate organic waste for collection, transported to a centralised
339 facility, or processed on site. Recycling is mandatory in Austin with rules also in places for
340 food waste separation – like New York City recycling this was rolled out in a staggered way
341 focusing on large business first (see Appendix A).

342 **Type of business** – In Charlotte under State regulation (North Carolina) businesses that hold
343 ‘on-premises permits’ for malt beverages, wine or mixed beverages are permitted to
344 separate all recyclable beverage containers. In Portland, Philadelphia and Austin there is a
345 requirement for businesses in the food industry to set up interventions for food waste.

346 **Other** – Business’s in Chicago that hold a business license and have a contract for private
347 garbage collection are required to recycle under the Chicago High Density Residential and
348 Commercial Source Reduction and Recycling Ordinance. The basic requirement for
349 commercial establishments is to recycle three items. In Nashville there is a requirement for
350 garden waste to be separated.

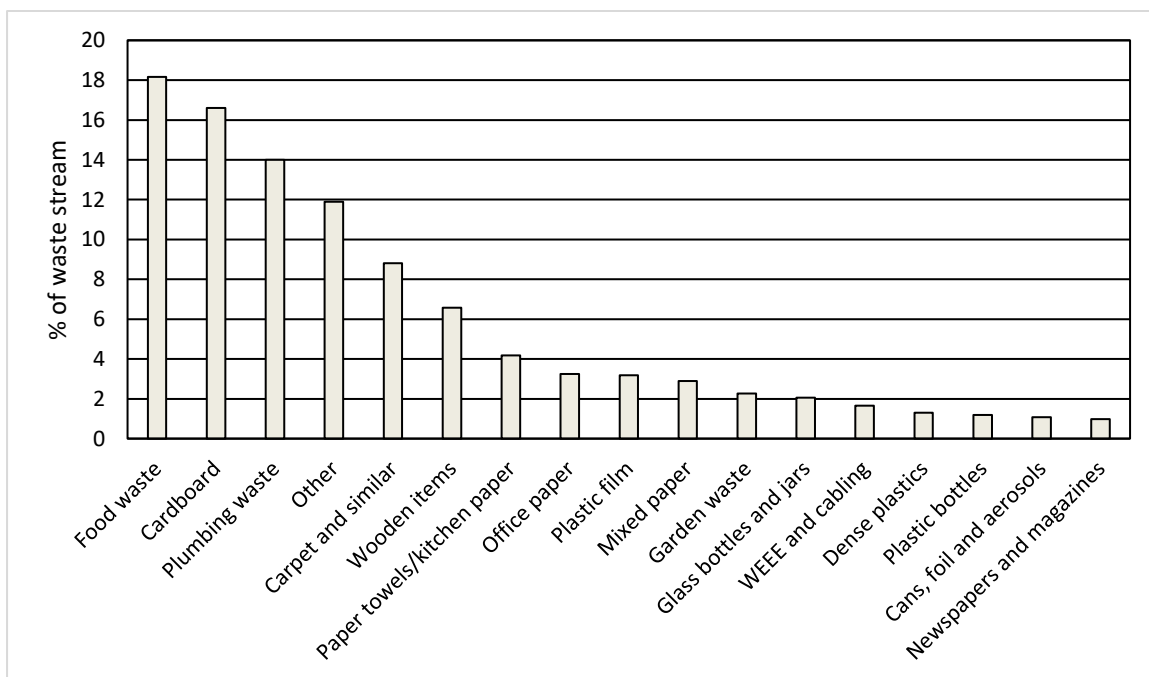
351 ***4. Stage 2 - Waste generation and composition from SMEs***

352 ***4.1 – Results***

353 Figure 3 presents a breakdown of the overall composition of C&I waste sampled. In total 2.8
354 tonnes of waste were generated from the 62 businesses sampled over the week of analysis.
355 The waste stream was heterogenous with food waste (18.2%) and cardboard (16.6%) being
356 the prominent materials. For brevity the materials were grouped into primary classifications

357 based upon their composition – a definition of these terms is presented in Table 4. Table 4
 358 also shows the breakdown of composition based on these primary classifications and
 359 descriptive statistics. Overall 28.7% of the waste sampled was classified as dry recyclables
 360 that are widely recyclable, a further 7.3% possibly recyclable and 49.6% biowaste. Although
 361 the businesses sampled were micro or small businesses there was significant variation in the
 362 quantities of waste generated with the median 16.7 kg per week. The two main sectors
 363 sampled were SIC G Wholesale and Retail and SIC I Accommodation and Food Service
 364 Activities. Further breakdown of the results for these sectors are presented in Appendix B
 365 (see e-component).

366



367

368 **Figure 3 Overall composition of the residual waste sampled (2.8 tonnes)**

369 **Table 4: Breakdown of composition of residual waste from all businesses sampled (n=62)**

Primary classification	Definition	Total sample		Kg per business per week				
		Weight (kg)	% of waste sampled	Mean	Median	High	Low	Standard deviation
Total sampled	-	2,870	-	46.4	16.7	267.0	0.6	69.0
A. Widely recyclable dry materials	Dry materials collected by >80% local authorities: Recyclable paper, card, cans, foil, aerosols, plastic bottles, glass	826	28.7	13.3	3.4	170.4	0.0	26.7
B. Possibly recyclable	Materials that can be recycled but limited services: Drinks cartons, coffee cups, shredded paper, textiles, other metals, dense plastics, batteries	209	7.3	3.4	1.8	21.3	0.0	4.5
C. Recyclable paper and card	All paper and card including shredded paper and coffee cups	712	24.8	11.5	2.4	173.8	0.0	25.9
D. Food waste only	Food only	521	18.2	8.4	0.7	161.0	0.0	25.6
E. Biowaste (excluding paper and card)	All organic material excluding paper and card. This includes food, garden waste, hair	713	24.8	11.5	1.1	196.0	0.0	31.5

F. All Biowaste	As per E plus all paper and cardboard	1426	49.6	23.0	5.2	224.8	0.0	46.1
G. Trade	Trade specific wastes such as carpet, plumbing waste	892	31.0	14.4	1.0	254.1	0.0	44.4
H. Miscellaneous	All other items	205	7.1	3.3	0.8	224.8	0.0	46.1

370

371 **4.2 Discussion**

372 The results highlight the complexities of the C&I waste stream both in terms of levels of
373 waste generated but also the composition of the stream. The results indicate significant
374 levels of resource leakage from the SMEs sampled. Of the total waste sampled 28.7% was
375 widely recyclable dry materials with a median value of 3.4 kg per business per week. 49.6%
376 was biowaste with a median of 5.2 kg per business per week. When focusing on SIC G
377 Wholesale and Retail levels of widely recyclable materials were higher at 45.2% with a
378 median of 4.9 kg per business per week (see Appendix B). For SIC I Accommodation and
379 Food Service Activity food made up 49.3% of the sample with a median of 21.5 kg being set
380 out per business per week. When considering all biowaste businesses generated for SIC I a
381 median of 25.4 kg per week with it making up 74.1% of all the waste sampled in the sector.
382 Despite the requirement of businesses to adhere to the waste hierarchy and recycle there is
383 seemingly little to no enforcement of these regulations. 61% of businesses sampled stated
384 that they did not recycle at all, and no businesses were engaged in segregating food waste.
385 From interviews the barriers to recycling included the will to recycle, spatial constraints,
386 costs and access to services – these are well-documented in studies by the Federation of
387 Small Businesses (2011), GHK (2010), Parsons and Kriwoken (2009), Radwan et al (2010) and
388 the Waste Resources Action Programme (2011).

389 **4.3 Impacts of policy interventions on resource flows**

390 Based on the review of waste management in 42 cities a series of scenarios were developed
391 based on if the identified recycling and biowaste separation policies were implemented in
392 England along with the government's proposal for businesses to have separate collections

393 for dry recycling, glass and food – see Table 5 which contains an explanation of each
394 scenario. Scenario A was based on if there was a blanket mandatory requirement for all
395 businesses to recycle and segregate biowaste, as per the system in San Francisco and
396 proposal by the government – this would lead to 1,539 kg/week (55.0%) of residual waste
397 from the businesses sampled being collected through recycling and biowaste programmes.
398 However, the scenario highlights the diversity of the SME waste stream and 45.0% of
399 material would remain in the residual stream. Scenario B - mandatory dry recycling for all
400 businesses would lead to the diversion of 825.9 kg/week (29.6% of the total waste
401 sampled). Under Scenario F the mandatory segregation of organics from all food businesses,
402 408.3 kg/week of food waste (14.2% of the total waste sampled) and 616.4 kg/week of all
403 biowaste (21.4% of the total waste sampled) would be diverted. It is noted that the
404 thresholds requiring mandatory recycling and organic separation applied in some
405 states/cities were far higher than the waste generation levels of the SMEs sampled. For
406 example, the implementation of food waste requirements in New York (Scenario G) would
407 not impact upon any of the SMEs in this study. The Californian and Charlotte inspired
408 Scenarios (C, D and E) based on the quantities of waste generated would have limited
409 impact with Scenario C having the biggest effect requiring 12 SMEs to recycle diverting
410 500.2 kg per week.

411

412

413

414 **Table 5: Possible impact on waste diversion from SMEs if identified policy was**
 415 **implemented**

Scenario - requirement	Based on	Number of business required to comply (n=62)	Impact on weight of waste separated – kg/week	Would lead to % diversion of total residual waste stream
Dry recycling and biowaste				
A. Mandatory dry recycling and biowaste separation	San Francisco/English government proposal	62	+1,539	55
Dry recycling only				
B. Mandatory dry recycling for all businesses	Washington/New York/Portland/Pennsylvania/Austin/Seattle/Calgary	62	+825.9	29.6
C. Businesses generating >4 yd ³ of waste per week required to segregate dry recyclables	California	12	+500.2	17.4
D. Businesses generating >16 yd ³ of waste per week required to segregate paper and card	Charlotte	4	+192.9	6.7

Biowaste only

E. Businesses generating >4 yd ³ of organic waste per week required to segregate organics	California	2	+331.5	11.5
F. Mandatory food/biowaste separation food businesses only	Portland/Austin	9	+408.3 (food only) +616.4 (all biowaste)	14.2 21.4
G. Mandatory food/organic separation food businesses based on size (see Appendix A)	New York	0	0	0

416

417 **5. Conclusion**

418 In their 2015 report on the Circular Economy the Ellen MacArthur Foundation (2015) pose
419 the question ‘what should an ideal European recycling system look like?’. This study
420 highlights that current system in England for SMEs is certainly far from ‘ideal’ with valuable
421 resources being wasted. Based on the data collected from SMEs sampled 53.5% of the total
422 residual waste sampled was dry recycling or biowaste that could be diverted from the
423 residual stream. 61% of businesses in the study did not recycle supporting existing literature
424 that despite regulations being in place many SMEs are not engaged in segregating their
425 waste. Whilst there is policy stipulating that SMEs should be reducing, reusing and recycling
426 waste this policy is being poorly implemented. Based on the scenarios modelled an
427 additional 1,539kg of recycling and biowaste could be collected each week from the 62

428 SMEs modelled – at present this waste is going to landfill or energy from waste plants – as
429 such resources are being wasted.

430 The research highlights the patchwork of policies in place globally regarding the
431 management of the C&I waste stream. The evaluation of policies on mandatory recycling
432 and organic segregation presents more questions than answers. Whilst some cities such as
433 San Francisco have pioneering and well-established policies, for 64% of cities evaluated
434 there was no requirement for businesses to recycle at all. Similarly, to England, the waste
435 stream has been overlooked with the focus being on household waste. The research also
436 highlights the complexities of the C&I waste stream due to the varying levels of waste being
437 generated, and diverse range of materials within the stream.

438 Further research should focus on better understanding how the mandatory recycling
439 schemes identified are being enforced, if at all, and what impact they have had on resource
440 flows and SME behaviour. Similar research is needed to understand what policy and
441 interventions globally are being adopted to promote the reduction and reuse of materials
442 from SMEs.

443 If the principles of the Circular Economy are to be achieved and if we want to develop
444 circular cities, it is imperative that global policy makers need to work to develop more
445 effective systems for the management of C&I and in particular work to improve services to
446 SMEs to capture resources which being wasted. It is estimated the C&I waste sector has an
447 annual growth rate of 6.7% but yet globally there are gaps in our knowledge on how much
448 C&I waste is generated, how businesses manage their waste, and policy across jurisdictions.
449 Further research is needed to fill these knowledge gaps. We need to better understand how
450 cities are managing C&I to help us plan and develop plan a *smarter* system. Under existing

451 waste management systems wastes are categorised and managed based upon where they
452 were generated be it households, institutions, commerce or industry. We need to be
453 developing more holistic systems that place the *resources* at the heart of global waste
454 policies.

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Appendix A Data tables on approaches towards C&I waste in 42 cities evaluated

Table A1 Overview of mandatory requirement to recycle and separate out biowaste in the cities analysed

City	Mandatory	Detail
Los Angeles (California)	Dry recycling: Partly	STATE: From July 2012 recycling mandatory required in California for businesses generating >4 yd ³ of solid waste/week (California Assembly Bill No. 341, 2011).
	Biowaste: Partly	STATE: From April 2016 businesses generating >8yd ³ of organic waste/week required to have an organic waste recycling service, threshold reduced to >4 yd ³ from January 2017. From January 2019 businesses generating >4 yd ³ of solid waste/week required to separate organics. If by summer/fall 2021 the disposal of organic waste has not reduced to 50% of the level in 2014 the requirement reduces to businesses generating >2 yd ³ of solid waste/week. Under the Bill organic waste means food waste, green waste, landscape and pruning waste, non-hazardous wood waste, and food-soiled paper waste that is mixed in with food waste (California Assembly Bill No. 1826, Chapter 727, 2014).
San Jose (California)	Dry recycling: Partly	STATE: See Los Angeles
	Biowaste: Partly	STATE: See Los Angeles

City	Mandatory	Detail
San Diego (California)	Dry recycling: Fully	STATE: See Los Angeles CITY: Additional requirements to those at state level. From February 2008 businesses >20,000 ft ² were required to recycle reducing to >10,000 ft ² in January 2009 and all businesses from January 2010. Ordinance Bill requires the collection of at least plastic and glass bottles and jars, paper, newspaper, metal containers, and cardboard (San Diego Municipal Code – Division 7 Recycling Ordinance, 2007).
	Biowaste: Partly	STATE: See Los Angeles
San Francisco (California)	Dry recycling: Fully	STATE: See Los Angeles CITY: Mandatory recycling introduced in 2009 before state regulations (San Francisco Mandatory Recycling & Composting Ordinance 100-09, 2009).
	Biowaste: Fully	STATE: See Los Angeles CITY: Mandatory composting (including food) introduced in 2009 before state regulations (San Francisco Mandatory Recycling & Composting Ordinance 100-09, 2009).

City	Mandatory	Detail
Washington (District of Columbia)	Dry recycling: Fully	DISTRICT: Enacted the DC Solid Waste Management and Multi-Material Recycling Act of 1988 and updated in 2010. All businesses required to recycle paper, card, and containers (metal/glass/plastic).
	Biowaste: No	N/a
Chicago (Illinois)	Dry recycling: Partly/Mostly	CITY: All businesses that are required to have a Chicago business license and contract for private garbage collection are required to recycle. The basic requirement for commercial establishments is to recycle three items. Post-collection separation is not accepted unless a written waiver is received from the Department of Streets and Sanitation i.e. source separation required. Under the waiver the business must demonstrate that implementing source separation recycling would cause undue economic, safety or space hardship and provide to the City results of an analytical waste audit (Chicago High Density Residential and Commercial Source Reduction and Recycling Ordinance)
	Biowaste: No	N/a
Boston (Massachusetts)	Dry recycling: Fully	STATE: Waste Ban, 310 CMR 19, requires certain materials including glass, plastics and paper to be recycled. Businesses located in Boston, must enter into private contracts with haulers in order to recycle.

City	Mandatory	Detail
	Biowaste: Partly	STATE: From October 2014 the disposal of commercial organic wastes by businesses and institutions that generate >1 tonne of these materials per week is banned.
New York (New York)	Dry recycling: Yes	CITY From 1992 businesses required to recycle and from August 2016 recycling of metal, glass, plastic, beverage cartons, paper and cardboard has been mandatory. If textiles or yard/plant waste > 10% of the business's waste in any month, they are required by law to separate and recycle. (Local Law 87 of 1992) NEED SUBSEQUENT LAWS
	Biowaste: Partly	CITY From July 2015 certain businesses required to separate organic waste for collection by a private carter, transport it to a centralised facility, or processed on site. Applies to: food service establishment in a hotel with >150 rooms; food vendor in arenas or stadiums with seating capacity of >15,000 people; food manufacturers with a floor area of 25,000 ft ² ; food wholesaler with a floor area of >20,000 ft ² . Section 1-11 of Title 16 of the Rules of the City of New York extends the requirement to the following from 15/8/2018: a food service establishment with a floor area space of >15,000 ft ² ; a food service establishment that is part of a chain of 100 or more locations in the city and that (i) operate under common ownership or control; (ii) are individually franchised outlets of a parent business; or (iii) do business under the same corporate name; and a retail food store that has a floor area >25,000 ft ² .

City	Mandatory	Detail
Charlotte (North Carolina)	Dry recycling: Partly	<p>COUNTY: Since January 2002 businesses generating >16yd³ of waste/week required to separate corrugated cardboard and office paper for recycling. A business may contract with a collector or take materials to a centralised collection point. A business can commingle these materials with the rest of their waste if they are contracting with a certified mixed waste recycler who will do the separation for them.</p> <p>STATE: requires holders of on-premises alcohol permits to recycle all recyclable beverage containers sold on the premises. (G.S 18B-1006.1)</p>
	Biowaste: No	N/a
Portland (Oregon)	Dry recycling: Fully	<p>CITY: From January 1996 commercial customers required to set up recycling systems and ensure that at least 50 percent of their waste materials recycled. From August 2014 all businesses required to recycle all paper and containers including cans, plastic packaging, glass bottles and cartons.</p>
	Biowaste: Partly	<p>CITY: From August 2014 food waste generating businesses required to separate all food waste from mixed waste. Bureau of Planning and Sustainability determines which businesses are subject to this requirement based on estimates of the amount of food waste generated.</p>

City	Mandatory	Detail
Philadelphia (Pennsylvania)	Dry recycling: Fully	STATE: Businesses required to fill out a recycling plan on-line explaining the recycling activities of the business and details of their contractor. The Certificate from the recycling plan should be posted in a conspicuous location and readily available for inspection. Businesses required to show pertinent information on the recycling system to employees and actively comply with the provisions in the Recycling Plan. Businesses are mandated to recycle materials generated within the normal operation of their business this includes; paper, cardboard, plastic, glass, metal cans. Under the regulations there are no exemptions. Penalties for noncompliance can amount to \$300 per violation per day. (Pennsylvania Act 101 and City Ordinance 1251(A)).
	Biowaste: Partly	CITY: Businesses that generate food waste are required to either install a garbage disposer or arrange for twice-weekly collection of organic waste. (Chapter 10-722 of the Philadelphia Code)
Nashville (Tennessee)	Dry recycling: Partly	CITY: The following materials banned from solid waste: July 2013 - corrugated cardboard and corrugated cardboard boxes, July 2015 - electronic waste. Effective July 2013 each hauler shall offer recycling services and may charge a reasonable fee for the provision of recycling services
	Biowaste: Partly - yard waste	CITY: From July 2011 yard waste (including leaves, limbs, brush, grass clippings) banned from being placed in mixed waste.

City	Mandatory	Detail
Austin (Texas)	Dry recycling: Fully	CITY: Mandatory now - introduced in increments. Businesses required to recycle from October 2014 if premises >50,000 ft ² ; October 2015 if premises >25,000 ft ² ; October 2016 if premises >5,000 ft ² ; and 1/10/2017 for all other non-residential premises.
	Biowaste: Partly	CITY: Food enterprises that require a food permit under Section 10-3-61 required to operate onsite diversion of organic materials effective from the following: October 2016 where the food enterprise is >15,000 ft ² ; October 2017 where enterprise > 5,000ft ² ; and October 2018 for all food enterprises that hold a food enterprise permit.
Seattle (Washington)	Dry recycling: Fully	CITY From January 2005 all businesses required to separate paper (including paper cups), and cardboard for recycling. From July 2014 required to separate glass bottles and jars, plastic cups, bottles and jars, and aluminium and tin cans for recycling. Some exceptions e.g. if existing commercial structures that do not have adequate storage space.
	Biowaste: Fully	CITY: From January 2005 all businesses required to separate yard waste for recycling. From January 2015 businesses required to separate food waste and compostable paper for recycling or process their food waste onsite. Some exceptions e.g. if existing commercial structures that do not have adequate storage space.

City	Mandatory	Detail
Calgary	Dry recycling: Fully	CITY: Business that generate the following items must recycle them. November 2016 - Paper, cardboard, glass and metal food and beverage containers, foil, plastic containers, plastic bags, cartons, ferrous and non-ferrous scrap metals, clear polyethylene film, wood.
	Biowaste: Fully	CITY: November 2017 - Businesses must divert food and yard waste.

Cities with no mandatory recycling and biowaste separation requirements: Auckland, Baltimore, Brisbane, Christchurch, Columbus, Dallas, Denver, Detroit, El Paso, Fort Worth, Hamilton, Houston, Indianapolis, Jacksonville, Las Vegas, Louisville, Melbourne, Memphis, Montreal, Oklahoma City, Ottawa, Perth, Phoenix, San Antonio, Sydney, Toronto, Wellington

Appendix B Breakdown of waste composition results

SIC G Wholesale and Retail

31 of the total businesses sampled were from this SIC code (see A2). 45.2% of the materials sampled were widely recyclable with a median of 4.9 kg per business per week. 41.5% was recyclable paper and card with a median of 4.3 kg per business per week. For 12 of the businesses over half of the waste stream was widely recyclable and for 16 over half was biowaste.

Table A2: Breakdown of composition of residual waste for SIC G – Wholesale and retail (n=19)

Primary classification	Total sample for SIC		Kg per business per week				
	Weight (kg)	% of waste sampled for SIC	Mean	Median	High	Low	Standard deviation
Total sampled	1,013.0	-	32.7	18.3	257.0	0.6	48.3
A. Widely recyclable dry materials	458.0	45.2	14.8	4.9	170.4	0.0	31.6
B. Possibly recyclable	96.1	9.5	3.1	1.8	16.0	0.0	3.4
C. Recyclable paper and card	420.7	41.5	13.6	4.3	173.8	0.0	31.4
D. Food waste only	99.4	9.8	3.2	0.4	51.0	0.0	9.1

E. Biowaste (exl paper and card)	176.1	17.4	5.7	1.1	62.1	0.0	13.8
F. All Biowaste	596.8	58.9	19.3	5.5	224.8	0.1	40.8
G. Trade	158.0	15.6	5.1	0.5	47.8	0.0	10.5
H. Miscellaneous	97.8	9.7	3.2	0.6	33.6	0.0	7.4

5.2.3 SIC I Accommodation and Food Service Activities

Samples were taken from 9 businesses under this SIC code – all were from food services including cafes and restaurants with a median of 32.1 kg being set out (see A3). Unsurprisingly food made up 49.3% of the sample with a median of 21.5 kg being set out per business per week. When considering all biowaste, businesses generated a median of 25.4 kg per week making up 74.1% of all the waste sampled in the sector. 22.6% of the waste was widely recyclable with a median yield of 4.9 kg per week.

Table A3: Breakdown of composition of residual waste for SIC I – Accommodation and food service activity (n=9)

Primary classification	Total sample for SIC		Kg per business per week				
	Weight (kg)	% of waste sampled for SIC	Average	Median	High	Low	Standard deviation
Total sampled	829.0	-	92.1	32.1	194.6	15.1	87.3
A. Widely recyclable dry materials	187.6	22.6	20.8	11.3	57.4	2.5	21.2

B. Possibly recyclable	43.6	5.3	4.8	2.5	17.2	0.7	4.8
C. Recyclable paper and card	128.2	15.5	14.2	4.0	45.5	0.0	16.8
D. Food waste only	408.3	49.3	45.4	21.5	161.0	3.9	51.2
E. Biowaste (exl paper and card)	486.2	58.6	54.0	23.6	196.0	4.5	63.2
F. All Biowaste	614.4	74.1	68.3	25.4	217.0	6.6	19.4
G. Trade	75.5	9.1	8.4	4.0	49.7	0.0	14.8
H. Miscellaneous	36.1	4.4	4.0	3.8	13.8	0.0	4.1
