Building linked open data about carbon savings

The Data Commons Scotland project | Greg Singh; Anna Wilson; Hannah Hamilton; Ashley McClenaghan | October 2021

This is a *walk-through* of how we can build **linked open data** (LoD) about **carbon savings** from dissimilar data sources.

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1. Measurement data → CSV

1.1. Sources

We take examples of meaurement data from 4 sources:

- Alloa Community Enterprises - reused furniture
- Stirling Community Food - redistributed food
- Stirling Council - household recycling bins
- The Fair Share - reused, student-oriented items.

1.2. Deriving the same information from the dissimilar sources

Their data is dissimilar, for example:

- 3rd sector reporting *vs.* local government reporting
- emailed Excel files *vs.* CKAN hosted CSV files
- kilograms *vs.* tonnes
- various means of indicating dates
- various ways of categorising the stuff that gets reused.

…but our end goal is to derive the same information from each of them. This information can be seen in the `carbon-savings.csv` CSV file that contains the results of our efforts. Here's a snippet of data from that file:

occurrence-date	scottish-carbon-metric-material	tonnes-weight	enabler	enabler-specific
2018-02-28	Wood	0.385	Alloa Community Enterprises	55 items of Furniture (Chair, Kitchen, Dining or Wooden)
2021-01-29	Food and Drink Waste (wet AD)	0.28012	Stirling Comunity Food	Used for human-food, bio-etc & sanctuary
2021-01-03	Glass (mixed colours)	3.5	Stirling Council	Balfron
2019-12-31	Textiles & Footwear	0.57644	The Fair Share	autumn semester

1.3. The process

To derive that CSV file, we do the following for each source:

a. parse the essential values out of the source files

b. derive and standardise values

   i. mapping text values into controlled, canonical *code lists* (e.g. the Scottish Carbon Metric's [carbon-metric] list of `materials`; and our list of carbon-savings `enabler` organisations)

   ii. appropriately scaling numbers (e.g. weight amounts to `tonnes`)

   iii. applying a standard format to dates

   iv. encode source-specific data that would be useful to propogate, into the `enabler-specific` field

c. output as CSV.

Our process is basically: messy data → *tidy* CSV data.
The Tidy Data paper [tidy-data] provides good rationale for and examples of this process, generalised.

1.4. Design decisions

- Use The Scottish Carbon Metric [carbon-metric] as the basis for measuring carbon savings. This is refered to via the `scottish-carbon-metric-material` column; and we will discuss it further in Section 2.
- Accounting & reporting procedures often batch into a single carbon-savings record, all of the instances of *same material-class* reuse/recycling that have occurred within an interval of time. The `occurrence-date` column captures the end date of those intervals.
- Include the `enabler-specific` column to allow `enabler`s to: propogate additional information; and to report measurements at an additional level of granularity (see the primary key

explanation, later).

- Reduce "double accounting" by trying to ensure that: the data contains no records where one carbon savings `enabler` 'feeds' the same reuse/recycling item to another `enabler`, within some (significant-for-use) duration.

1.5. Per-source *walk-throughs*

In this section we walk-through the *measurement data → CSV* process, for each source; outlining some per-source specifics.

1.5.1. Alloa Community Enterprises - reused furniture

Alloa Community Enterprises' (ACE) furniture reuse initiative has been running since 1984, helping prevent furniture from becoming waste.

ACE is in the process of publishing its data as open data. The following **samples** of measurement data have been taken from a draft of that work.

Here's a snipped image of ACE's measurement data:

	A	B	C	D	F
1	**Category**	**Items**	**Average Weight**	**Feb 18 nos**	**Feb 19 nos**
7	Furniture	Chair, Kitchen, Dining› or Wooden	7	55	82
46	Soft Furniture	Mattress, single	21	7	8

The main steps in processing ACE's measurement data (the snippet shown above) are:

a. Parse the essential values out of columns `A`-`D` & `F`

b. Derive and standardise values …

   i. We map each pair of `Category` & `Items` values, to a `scottish-carbon-metric-material` value. We build this mapping table as the `ace-to-carbon-metric.csv` CSV file. Here's a snippet of data from that file:

category	**item**	**material**
Furniture	Chair, Kitchen, Dining or Wooden	Wood
Soft Furniture	Mattress, single	Textiles and Footwear

   ii. Multiple columns `D` & `F` by column `C` and divide by 1000, to calculate the `tonnes-weight` value.

   iii. Map the headers of columns `D` & `F`, to establish the `occurrence-date` value.

   iv. Capture furniture type & count information in the `enabler-specific` value.

c. Output the end result as the CSV rows:

occurrence-date	scottish-carbon-metric-material	tonnes-weight	enabler	enabler-specific
2018-02-28	Wood	0.385	Alloa Community Enterprises	55 items of Furniture (Chair, Kitchen, Dining or Wooden)
2018-02-28	Wood	0.574	Alloa Community Enterprises	82 items of Furniture (Chair, Kitchen, Dining or Wooden)
2019-02-28	Textiles and Footwear	0.147	Alloa Community Enterprises	7 items of Soft Furniture (Mattress, single)
2019-02-28	Textiles and Footwear	0.168	Alloa Community Enterprises	8 items of Soft Furniture (Mattress, single)

1.5.2. Stirling Community Food - redistributed food

Stirling Community Food is a project that helps to reduce food waste in Stirling by collecting (from supermarkets & aggregators) excess and near-sell-by-date food, routing it away from waste bins, and making it available (for free) to the community.

Stirling Community Food is in the process of publishing its data as open data. The following **samples** of measurement data have been taken from a draft of that work.

Here's a snipped image of Stirling Community Food's measurement data:

	A	B	C	D	G	K	L	M	N	O
2					Recei					
3	Date		Neighbourly	Fareshare	Cooperative	Other	Grand Total	Waste (Kg)	Composted (Kg)	Donated to animal sanctuary (Kg)
4										
311	Thursday	28-Jan	52.7		17	18.39	88.1	2.85	0.48	54.65
312	Friday	29-Jan	32	255.52		0.6	288.1	12.5	8	

The main steps in processing Stirling Community Food's measurement data (the snippet shown above) are:

a. Parse the essential values out of columns `A-O`

b. Derive and standardise values …

   i. We map the 'outcomes' (i.e. how the food material got used) to a `scottish-carbon-metric-`

`material` value. We build this mapping table as the `stirling-community-food-to-carbon-metric.csv` CSV file. Here's the data from that file:

outcome	material
human-food, bio-etc & sanctuary	Food and Drink Waste (wet AD)
compost-indiv	Food and Drink Waste (Composting)

ii. Calaculate the total amounts of food materials for each of the outcome (converting from kgs to tonnes), to calculate the `tonnes-weight` value.

iii. Interpret column `B` to establish the `occurrence-date` value.

iv. Capture outcome information in the `enabler-specific` value.

c. Output the end result as the CSV rows:

occurrence-date	scottish-carbon-metric-material	tonnes-weight	enabler	enabler-specific
2021-01-28	Food and Drink Waste (wet AD)	0.08761	Stirling Comunity Food	Used for human-food, bio-etc & sanctuary
2021-01-28	Food and Drink Waste (Composting)	0.00048	Stirling Comunity Food	Used for compost-indiv
2021-01-29	Food and Drink Waste (wet AD)	0.28012	Stirling Comunity Food	Used for human-food, bio-etc & sanctuary
2021-01-29	Food and Drink Waste (Composting)	0.008	Stirling Comunity Food	Used for compost-indiv

1.5.3. Stirling Council - household recycling bins

Stirling Council set a precedent by being the first (and still only) Scottish local authority to have published open data about their bin collection of household waste.

The following **samples** of measurement data have been taken from that published data.

Here's a snipped image of Stirling Council's measurement data:

	B	C	E	F	H
1	Date	Route	Waste Collected	Quantity	Category
7	03/01/2021 12:14	Balfron	72 Mixed Glass	3.5	Recycling
35	04/01/2021 12:16	Bridge of Allan	107 Containers Stream	1.86	Recycling
249	10/01/2021 09:50	Killearn	106 Fibre (Paper & Card)	0.24	Recycling

The main steps in processing Stirling Council's measurement data (the snippet shown above) are:

a. Parse the essential values out of columns `B` - `C`, `E` - `F` & `H`

b. Derive and standardise values …

   i. We map column `E` to to a `scottish-carbon-metric-material` value. We build this mapping table as the `stirling-council-to-carbon-metric.csv` CSV file. Here's a snippet of data from that file:

Waste Collected	material
106 Fibre (Paper & Card)	Mixed paper and board
107 Containers Stream	Average Plastics
72 Mixed Glass	Glass (mixed colours)

   ii. Use column `F` as the `tonnes-weight` value.

   iii. Interpret column `B` to establish the `occurrence-date` value.

   iv. Note the `Route` information in the `enabler-specific` value.

c. Output the end result as the CSV rows:

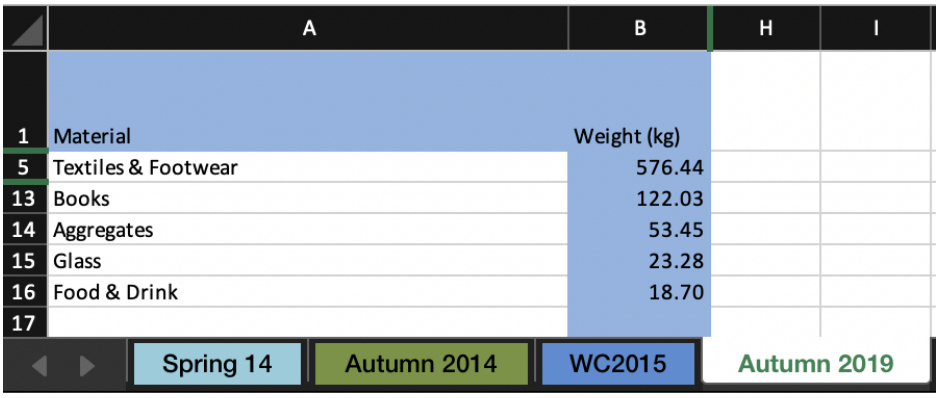
occurrence-date	scottish-carbon-metric-material	tonnes-weight	enabler	enabler-specific
2021-01-03	Glass (mixed colours)	3.5	Stirling Council	Balfron
2021-01-04	Average Plastics	1.86	Stirling Council	Bridge of Allan
2021-01-10	Mixed paper and board	0.24	Stirling Council	Killearn

1.5.4. The Fair Share - reused, student-oriented items

The Fair Share is a university based, reuse store. It accepts donations of second-hand books, clothes, kitchenware, electricals, etc. and sells these to students.

The Fair Share is in the process of publishing its data as open data. The following **samples** of measurement data have been taken from a draft of that work.

Here's a snipped image of The fair Share's measurement data:



	A	B	H	I
1	Material	Weight (kg)		
5	Textiles & Footwear	576.44		
13	Books	122.03		
14	Aggregates	53.45		
15	Glass	23.28		
16	Food & Drink	18.70		
17				

Spring 14 | Autumn 2014 | WC2015 | Autumn 2019

The main steps in processing The Fair Share's measurement data (the snippet shown above) are:

a. Parse the essential values out of columns `A` - `B`, & from the worksheet name

b. Derive and standardise values …

   i. We map column `B` to to a `scottish-carbon-metric-material` value. We build this mapping table as the `the-fair-share-to-carbon-metric.csv` CSV file. Here's a snippet of data from that file:

(The Fair Share's) Material	material
Textiles & Footwear	Textiles & Footwear
Books	Books
Aggregates	Aggregates (Rubble)
Glass	Glass (mixed colours)
Food & Drink	Food and Drink Waste (wet AD)

   ii. Use column `B` divided by 1000, as the `tonnes-weight` value.

   iii. Map the worksheet's name to establish the `occurrence-date` value.

   iv. Note the university's semester in the `enabler-specific` value.

c. Output the end result as the CSV rows:

occurrence-date	scottish-carbon-metric-material	tonnes-weight	enabler	enabler-specific
2019-12-31	Textiles & Footwear	0.57644	The Fair Share	autumn semester
2019-12-31	Books	0.12203	The Fair Share	autumn semester
2019-12-31	Aggregates (Rubble)	0.05345	The Fair Share	autumn semester
2019-12-31	Glass (mixed colours)	0.02328	The Fair Share	autumn semester
2019-12-31	Food and Drink Waste (wet AD)	0.0187	The Fair Share	autumn semester

2. Reference data → CSVs

In this section we walk-through building our two reference (*axiomatic*) data CSVs.

2.1. Carbon metric

The *carbon impact* is a measure devised by Zero Waste Scotland (ZWS), to convey the whole-life carbon impact of waste, from resource extraction and manufacturing emissions, right through to waste management emissions. Its unit-of-measure is *tonnes of carbon dioxide equivalent* (CO_2eT).

This is a reasonable basis for measuring carbon savings so we will use it as *reference data*.

It is defined in The Scottish Carbon Metric document [carbon-metric]. For our purpose, its key data is in table 6.2. This contains per-material weight-multipliers that can be used to calaculate CO_2eT amounts.

Here's a snipped image of that table:

Waste Stream	Carbon Weighting
Textiles	100.00
Textiles and Footwear	84.70
Aluminium cans and foil	65.87
Footwear	31.17
Mixed Cans	27.80
Scrap Metal	16.07
Steel Cans	12.25

This table's data has been published as linked open data by our project, in previous work. See the `co2e-multiplier` files in this Git repo. But we will redo that work here so that that we can provide an explanatory walk-through.

We copy the table's data from its original PDF format into the more tractable `carbon-metric.csv` CSV file. Here's a snippet of data from that file:

material	multiplier
Textiles	100.00
Textiles and Footwear	84.70
Aluminium cans and foil	65.87
Footwear	31.17
Mixed Cans	27.80
Scrap Metal	16.07
Steel Cans	12.25

So, for our carbon savings data:

- `carbon-metric.csv` will be referenced as the basis for calculations.
- CO_2eT will be used as the primary unit-of-measure

For example, consider 1 tonne of (used) shoes…

If these were landfilled at a waste site then the *carbon impact* would be:

```
  (1 tonne) x (the `multiplier` value for `Footwear` from `carbon-metric.csv`)
= (1 tonne) x (31.17  CO2e)
= 31.17 CO2eT
```

Instead, if a reuse store sells them to its customers, it has made a *carbon saving* of 31.17 $CO2_eT$.

The term *carbon saving* is a little misleading. A better name for it might be *carbon impact deferrals* since all objects are eventually disposed of. But we won't pursue that philosphical totality in this document.

2.2. Enabler organisations

We describe the `enabler` organisations in `enablers.csv`. Here's the data from that file:

name	latitude	longitude
Alloa Community Enterprises	56.122913	-3.781621
Stirling Comunity Food	56.115672	-3.936217
Stirling Council	56.113345	-3.936807
The Fair Share	56.146389	-3.919833

3. CSVs → linked data

3.1. CSVs may be good enough

In Section 1 and Section 2 we *re-worked* the source data into CSV files with inconsistences rectified, text values mapped to cannocical code lists, and numeric & date values standardised. The resulting CSVs may not be as detailed or have all the nuances as their source data - but for the purpose of understanding *carbon savings*, they are **easy to use**, understand, consume and parse. Indeed, for many purposes and for use by non data experts, such CSVs will be good enough for publication as **open data** without further augmentation.

3.2. Describing our data using linked data vocabularies

Our CSVs have *implicit* meaning and linking. E.g.

- an `occurrence-date` value, *implicity* has the semantics of being a *date*
- a `carbon-metric-material` value in the measurements CSV, *implicity* is linked to the same `material` value in the reference data CSV.

For a standalone case study, this may be good enough but, for our data to become part of the global linked data graph [linked-data], we need to define its semantics *explicitly*, in standardised way. I.e. we need to describe our data using standard *linked data vocabularies*, to explain to everyone how to interpret our data and how it is linked to other data.

3.3. Using CSVW

CSV on the Web (CSVW) [CSVW] is a standardised mechanism for associating linked data semantics/*metadata* with CSV files.

It is nice because it allows us to keep our existing CSVs simple: unadulterated by linked data complications. (Although the CSVs must be of the *tidy* kind [tidy-data], as output from Section 1 and Section 2.)

Let's create CSVW files to give our CSVs linked data semantics.

3.3.1. CSVW for the `carbon-metric` reference data

`carbon-metric-metadata.json` contains the CSVW that gives linked data semantics to the `carbon-metric.csv` reference data.

Its features of interest are described below.

```
{
  "@context": "http://www.w3.org/ns/csvw",
  "tableSchema": {
    "columns": [{
      "name": "material",
      "titles": "material",
      "datatype": "string", ①
      "propertyUrl": "http://datacommonsscotland.org/linked-data/property/hasMaterial"
②
    }, {
      "name": "multiplier",
      "titles": "multiplier",
      "datatype": "decimal", ①
      "required": true, ③
      "propertyUrl": "http://datacommonsscotland.org/linked-
data/property/hasMultiplier" ②
    }, {
      "virtual": true, ④
      "propertyUrl": "http://www.w3.org/1999/02/22-rdf-syntax-ns#type",
      "valueUrl": "http://datacommonsscotland.org/linked-data/class/carbon-metric"
    }],
    "primaryKey": "material", ⑤
    "aboutUrl": "http://datacommonsscotland.org/linked-data/entity/carbon-
metric/{material}" ⑥
  }
}
```

① Assign standard (XMLSchema) data types to each of the CSV's columns.

② Define a new RDF predicate for each of the CSV's columns.

③ Declare the `multiplier` value to be mandatory.

④ Define the *virtual*, standard predicate rdf:type to say what *class* these rows are.

⑤ Declare the `material` value to be the primary key (and to be mandatory).

⑥ Define how to construct the URI (unique identifier) for each of the CSV's rows.

3.3.2. CSVW for the `enablers` reference data

`enablers-metadata.json` contains the CSVW that gives linked data semantics to the `enablers.csv` reference data.

Its new (not previously discussed) features of interest are described below.

```
{
  "@context": "http://www.w3.org/ns/csvw",
  "tableSchema": {
    "columns": [{
      "name": "name",
      "titles": "name",
      "datatype": "string",
      "propertyUrl": "http://datacommonsscotland.org/linked-data/property/hasName"
    }, {
      "name": "latitude", ①
      "titles": "latitude",
      "datatype": "decimal",
      "propertyUrl": "http://datacommonsscotland.org/linked-data/property/hasLatitude"
    }, {
      "name": "longitude", ①
      "titles": "longitude",
      "datatype": "decimal",
      "propertyUrl": "http://datacommonsscotland.org/linked-
data/property/hasLongitude"
    }, {
      "virtual": true,
      "propertyUrl": "http://www.w3.org/1999/02/22-rdf-syntax-ns#type",
      "valueUrl": "http://datacommonsscotland.org/linked-data/class/enablers"
    }],
    "primaryKey": "name",
    "aboutUrl": "http://datacommonsscotland.org/linked-data/entity/enablers/{name}"
  }
}
```

① The `latitude` and `longitude` values are optional, by CSVW default.

3.3.3. CSVW for the `carbon-savings` measurement data

`carbon-savings-metadata.json` contains the CSVW that gives linked data semantics to the `carbon-savings.csv` measurement data.

Its new (not previously discussed) features of interest are described below.

```
{
  "@context": "http://www.w3.org/ns/csvw",
  "tableSchema": {
    "columns": [{
      "name": "occurrenceDate",
      "titles": "occurrence-date",
      "datatype": "date",
      "propertyUrl": "http://datacommonsscotland.org/linked-
data/property/hasOccurrenceDate"
    }, {
      "name": "material",
```

```
      "titles": "scottish-carbon-metric-material",
      "datatype": "string",
      "propertyUrl": "http://datacommonsscotland.org/linked-
data/property/hasMaterial",
      "valueUrl": "http://datacommonsscotland.org/linked-data/entity/carbon-
metric/{material}" ①
    }, {
      "name": "tonnesWeight",
      "titles": "tonnes-weight",
      "datatype": "decimal",
      "required": true,
      "propertyUrl": "http://datacommonsscotland.org/linked-
data/property/hasTonnesWeight"
    }, {
      "name": "enabler",
      "titles": "enabler",
      "datatype": "string",
      "propertyUrl": "http://datacommonsscotland.org/linked-data/property/hasEnabler",
      "valueUrl": "http://datacommonsscotland.org/linked-
data/entity/enablers/{enabler}" ①
    }, {
      "name": "enablerSpecific",
      "titles": "enabler-specific",
      "datatype": "string",
      "propertyUrl": "http://datacommonsscotland.org/linked-
data/property/hasEnablerSpecific"
    }, {
      "virtual": true,
      "propertyUrl": "http://www.w3.org/1999/02/22-rdf-syntax-ns#type",
      "valueUrl": "http://datacommonsscotland.org/linked-data/class/carbon-savings"
    }],
    "primaryKey": ["occurrenceDate", "material", "enabler", "enablerSpecific"], ②
    "foreignKeys": [{
      "columnReference": "material",
      "reference": {
        "resource": "carbon-metric.csv", ①
        "columnReference": "material"
      }
    }, {
      "columnReference": "enabler",
      "reference": {
        "resource": "enablers.csv", ①
        "columnReference": "name"
      }
    }],
    "aboutUrl": "http://datacommonsscotland.org/linked-data/entity/carbon-
savings/{occurrenceDate}/{material}/{enabler}/{enablerSpecific}"
  }
}
```

① Declare the `material` & `enabler` values to be, in essence, links into the the `carbon-metric` &

`enablers` data.

② The primary key is a composite. Including `enablerSpecific` as a component of the primary key, allows the possibility for the `enabler` to report measurements at an additional level of granularity.

3.4. Generating an RDF graph

We use Swirrl's useful csv2rdf tool to generate a linked data/RDF graph of our data:

```
$ ls data/
carbon-metric.csv   carbon-savings.csv  enablers.csv ①

$ ls csvw/
carbon-metric-metadata.json carbon-savings-metadata.json    enablers-metadata.json ①

$ ./csv2rdf-0.4.6 -m minimal -t data/carbon-savings.csv -u csvw/carbon-savings-
metadata.json -o rdf/carbon-savings.ttl ②
$ ./csv2rdf-0.4.6 -m minimal -t data/carbon-metric.csv -u csvw/carbon-metric-
metadata.json -o rdf/carbon-metric.ttl ②
$ ./csv2rdf-0.4.6 -m minimal -t data/enablers.csv -u csvw/enablers-metadata.json -o
rdf/enablers.ttl ②

$ ls rdf/
carbon-metric.ttl   carbon-savings.ttl  enablers.ttl ③
```

① The inputs:
the CSV files containing the actual data, and
the CSVW files providing the linked data semantics/*metadata*.

② Run the `csv2rdf` tool against each CSV+CSVW input pairing.

③ The output: Turtle (`.ttl`) files which define an RDF graph of our data:
`carbon-savings.ttl`
`carbon-metric.ttl`
`enablers.ttl`

4. Using the linked data

4.1. Running a straightforward (SPARQL) query against the linked data

The linked data/RDF graph is defined by the Turtle files that we generated in Section 3.4. To help us examine and query that RDF graph, we load it into a *graph engine* (Blazegraph) that supports SPARQL queries.

First we load our Turtle files into Blazegraph's data store:

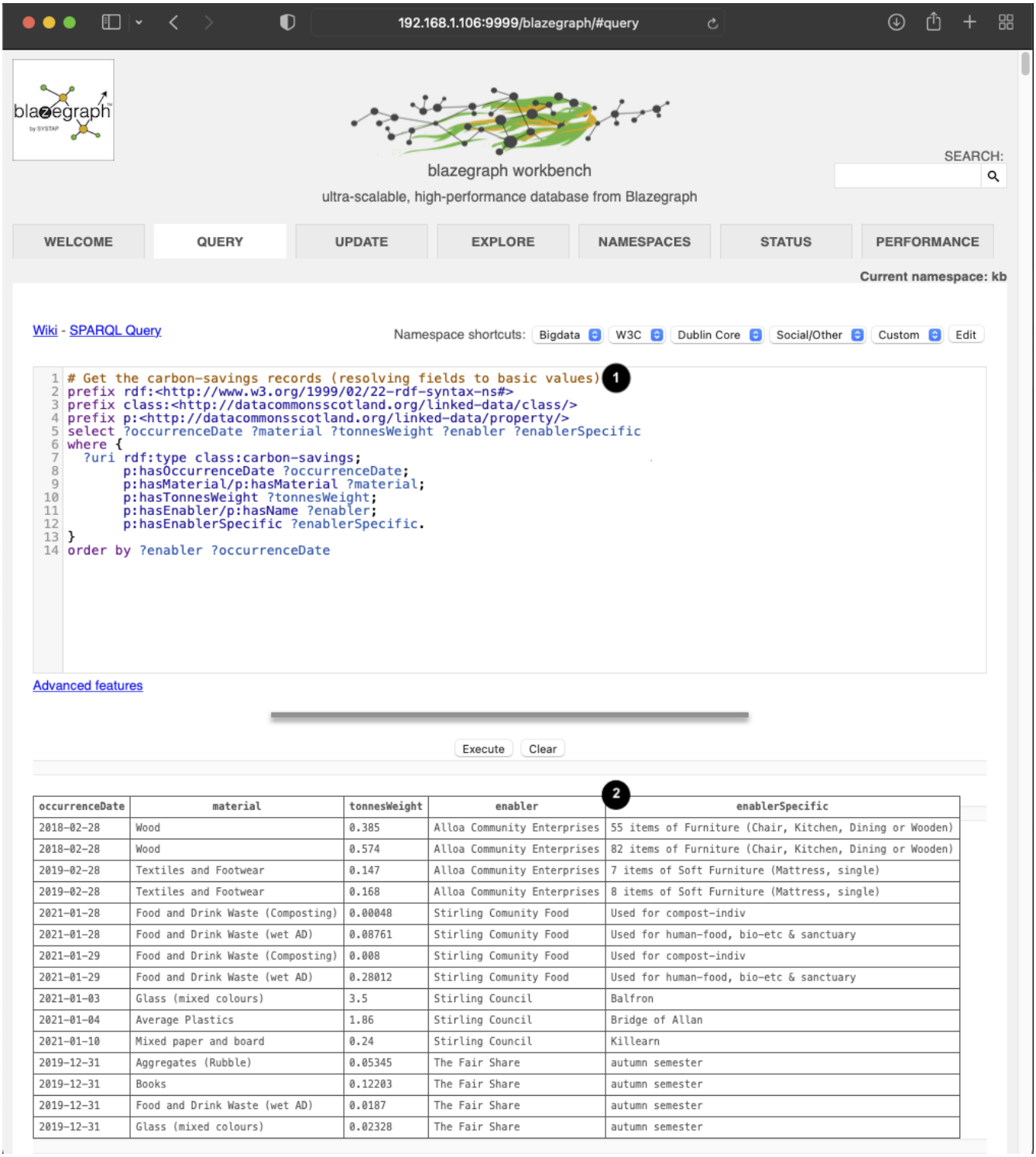
```
$ java -cp blazegraph.jar com.bigdata.rdf.store.DataLoader journal.properties *.ttl
...
Reading properties: journal.properties
Will load from: carbon-metric.ttl
Will load from: carbon-savings.ttl
Will load from: enablers.ttl
...
Load: 223 stmts added in 0.251 secs, rate= 888, commitLatency=0ms,
{failSet=0,goodSet=3}
```

Then we run Blazegraph's graph engine and SPARQL query service:

```
$ java -server -Xmx4g -jar blazegraph.jar
...
Welcome to the Blazegraph(tm) Database.

Go to http://192.168.1.106:9999/blazegraph/ to get started.
```

Opening that URL in a web browser, gives us a UI allowing us to exaime and query our RDF graph:



① Enter a SPARQL query. This example finds `carbon-savings` records then returns the specified field values.

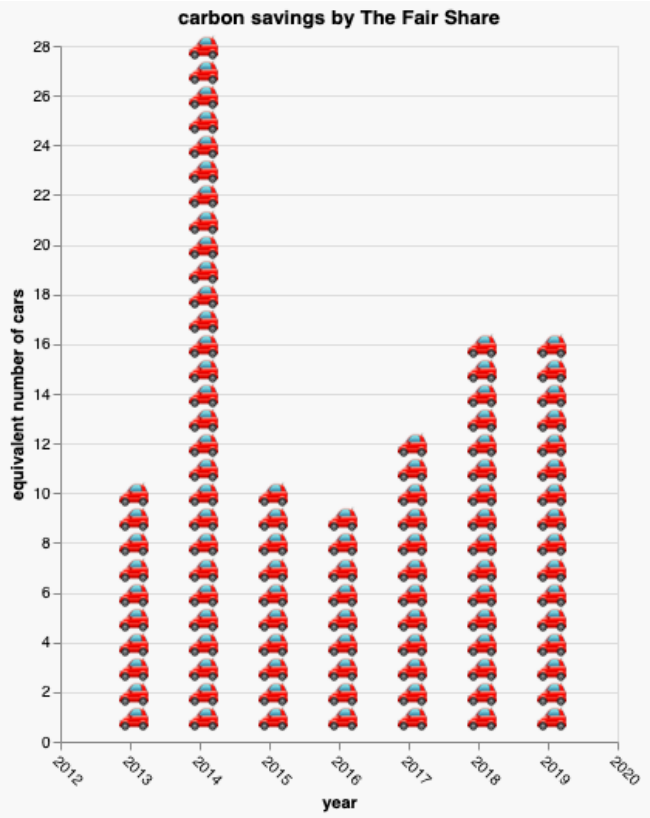
② See the results of that query.

4.2. Powering graphs with the linked data

Our prototype-6 Waste Matters Scotland webapp is powered by linked open data which was generated from larger samples of the datasets that were described in Section 1.

Let's take a look at two of the its linked data backed graphs about carbon savings.

4.2.1. The Fair Share - its carbon savings in terms of cars



The reuse work by this small store has yielded impressive carbon savings.

Each book, bowl, duvet, etc. reused through The Fair Share, is an item that has avoided becoming waste/pollution, and this is often estimated in terms of CO_2e (the carbon savings unit-of-measure).

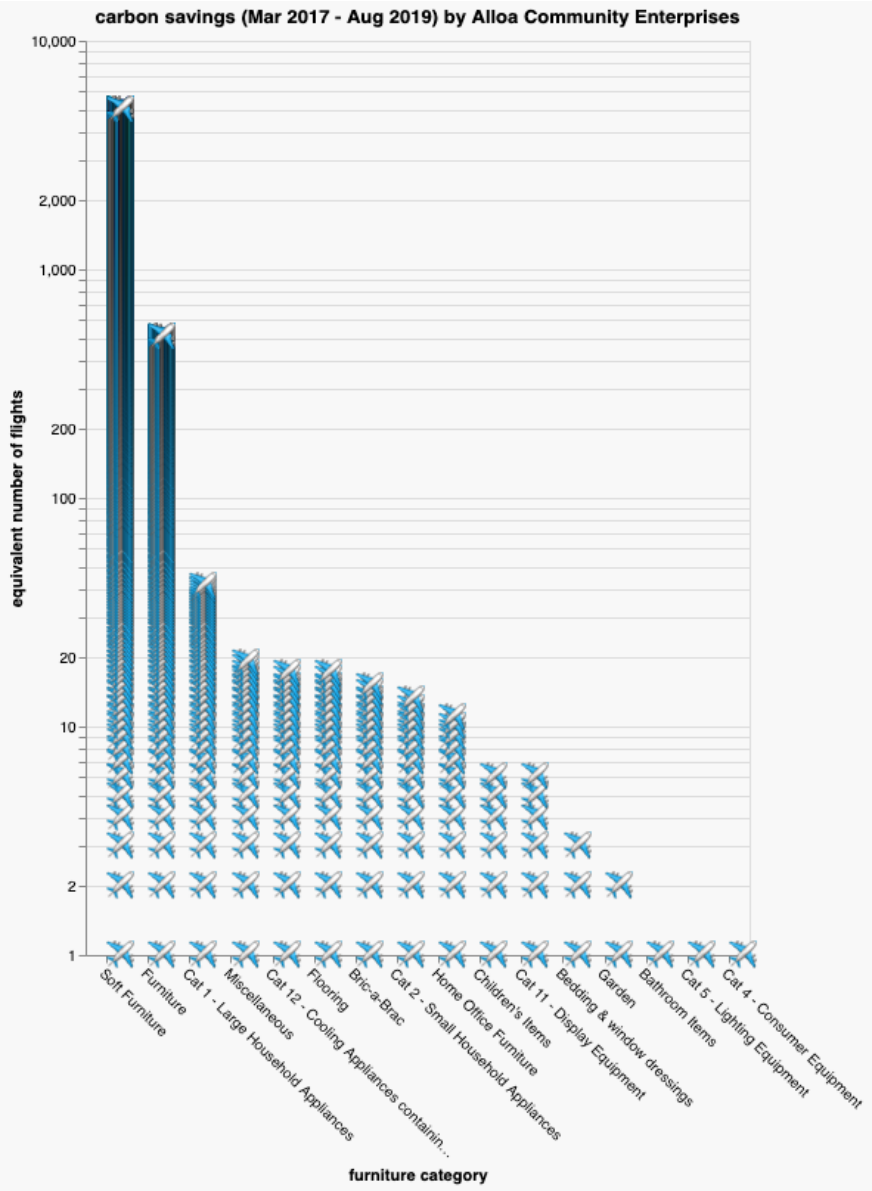
But by themselves, CO_2e values can be difficult to relate to so we convert them into in a more relatable measure: cars worth of CO_2e.

The average cost of using one car for one year is 4.1 tonnes of CO_2e. This incorporates as exhaust emissions, fuel supply chain and amortised car material for the average UK car. (This is a rough approximation based on figures from Carbon emissions in the lifetimes of cars and OVO Energy.)

So, we divide The Fair Share's carbon savings values by 4.1 to yield our cars worth of CO_2e values then use these to plot this graph.

(The 2014 spike was caused by an unusually large donation of textiles (duvet covers, sheets, pillowcases) from the student halls of residence.)

4.2.2. Alloa Community Enterprises - its carbon savings in terms of plane flights



The reuse of soft furniture (sofas, armchairs, matresses, etc.) alone (and during the short period sampled) has resulted in carbon savings equivalent to almost 5000 flights.

Each piece of furniture that is reused through the ACE initative, is an item that has avoided becoming waste/pollution. This is often estimated in terms of CO_2e (the carbon savings unit-of-measure).

In Section 1.5.1 we described how to estimate the CO_2e values for ACE by multipling the total weight of the items in each furniture category by an appropriate multiplier. These multipliers can be found in the `carbon-metric.csv` reference data file. Also, we have to map ACE's furniture categories to those multiplier records, and this is done via the `ace-to-carbon-metric.csv` mapping file.

But by themselves, CO_2e values can be difficult to relate to so we convert them into in a more relatable measure: flights worth of CO2e. The average cost of taking a one-way flight from Glasgow to Berlin is 202.5 kgs of CO_2e. (This was derived from these OVO Energy estimations which incorporate a plane's fuel use but not its build material.) We divide ACE's CO_2e values by 202.5 to yield our flights worth of CO_2e values then use these to plot this graph.

5. Concluding remarks

We finish with some open questions, points of interest arising, and ideas for future development.

5.1. Vocabularies, naming and structuring

Since we're dealing with measurement data, should we adopt *statistical* RDF vocabularities such as Data Cube and SDMX? We could use these to descibe additonal aspects of our data (e.g. to assocate `material` with the exact concept of SDMX's code list; to explicitly differentiate between identification and measurement dimension; to say more about our unit of measure). However, these would complicate the data model and, for our purpose, be more of a hinderance than a help.

CSVW *bakes in* support for vocabularies such as Dublin Core and schema.org. This makes it convenient to add `dc:description` and `schema:latitude` annotations/explanations to the data but, we haven't made use of this.

Should the class `carbon-metric` have been named `co2e-multipler` to reflect the more specific purpose of its data? And then, its `hasMaterial` property be redefined as `rdfs:label`? Naming and structuring the data is very important but, it isn't the focus of this piece of work, so we didn't *go all round the houses* to get it right here.

5.2. Be careful when comparing

This work is exploratory and uses small, non-comparable samples of data. If it were to be put into practice and based on fuller operational data then this approach could be used both to highlight and, to very roughly compare the carbon savings aspect of the `enabler` organisations. When used of the latter purpose - comparison - care should be exercised because of the dissimilar sizes of the `enabler` organisations and, dissimilar types of reuse materials.

Remember too that the 3rd sector `enabler` organisations are not working towards the single contractual objective of reuse but have additional laudable social objectives such as supportive employment, alleviating poverty, and promoting the local community.

On a more specific note about comparing: The `carbon-savings` records report on different time intervals so be careful to calculate comparable (say, per-day) amounts from the records.

5.3. Support needed for composition, revision and provenance

As data becomes available, it should be possible to *compose* it into an *accumulation* of open linked data about carbon savings.

Compose scenarios include:

- New data becoming available out-of-order.
- New data revising old data.
- New data conflicting with old data, where new and old have different provenances.

There are many approaches (temporal databases, distributed ledgers, linked data event streams) and interesting solutions (Fluree; TREE; even Git to some extent), that claim to support those *compose* scenarios and their related concerns (including ordering, durability, availablity, identity,

consensus, and branching).

However, using any of them would be future work.

5.4. Future development?

Would it be useful to develop the ideas from this exploratory walk through, into a prototype *app* for collecting and publishing carbon savings data? Maybe …if the focus were to be on 3rd sector and other non-government organisations - since government organisations already have outlets which publish their reuse data, such as SEPA, statistics.gov.scot and council websites.

We might build a (prototype) *app* which will allow organisations to: upload their carbon savings data; validate it; *compose* and *accumulate* it; and publish it as open linked data. The drivers of this work would be two-fold: Firstly, to highlight the carbon savings achievements (and other facets) of 3rd sector reuse orgs. Secondly (and more academically), to explore how linked open data concepts and technology can be practically applied to a (worthy) case-study.

References

- [carbon-metric] Zero Waste Scotland. The Scottish Carbon Metric. 2011.
- [tidy-data] Hadley Wickham. Tidy data. 2014.
- [linked-data] Tim Berners-Lee. Linked Data. 2006.
- [CSVW] W3C. CSV on the Web: A Primer. 2016.

Appendix A: Tidy CSV files

`carbon-savings.csv`

```
occurrence-date,scottish-carbon-metric-material,tonnes-weight,enabler,enabler-specific
2018-02-28,Wood,0.385,"Alloa Community Enterprises","55 items of Furniture (Chair,
Kitchen, Dining or Wooden)"
2018-02-28,Wood,0.574,"Alloa Community Enterprises","82 items of Furniture (Chair,
Kitchen, Dining or Wooden)"
2019-02-28,"Textiles and Footwear",0.147,"Alloa Community Enterprises","7 items of
Soft Furniture (Mattress, single)"
2019-02-28,"Textiles and Footwear",0.168,"Alloa Community Enterprises","8 items of
Soft Furniture (Mattress, single)"
2021-01-28,"Food and Drink Waste (wet AD)",0.08761,"Stirling Comunity Food","Used for
human-food, bio-etc & sanctuary"
2021-01-28,"Food and Drink Waste (Composting)",0.00048,"Stirling Comunity Food","Used
for compost-indiv"
2021-01-29,"Food and Drink Waste (wet AD)",0.28012,"Stirling Comunity Food","Used for
human-food, bio-etc & sanctuary"
2021-01-29,"Food and Drink Waste (Composting)",0.008,"Stirling Comunity Food","Used
for compost-indiv"
2021-01-03,"Glass (mixed colours)",3.5,"Stirling Council","Balfron"
2021-01-04,"Average Plastics",1.86,"Stirling Council","Bridge of Allan"
2021-01-10,"Mixed paper and board",0.24,"Stirling Council","Killearn"
2019-12-31,"Textiles & Footwear",0.57644,"The Fair Share","autumn semester"
2019-12-31,Books,0.12203,"The Fair Share","autumn semester"
2019-12-31,"Aggregates (Rubble)",0.05345,"The Fair Share","autumn semester"
2019-12-31,"Glass (mixed colours)",0.02328,"The Fair Share","autumn semester"
2019-12-31,"Food and Drink Waste (wet AD)",0.0187,"The Fair Share","autumn semester"
```

carbon-metric.csv

```
material,multiplier
"Textiles",100.00
"Textiles and Footwear",84.70
"Aluminium cans and foil",65.87
"Footwear",31.17
"Mixed Cans",27.80
"Scrap Metal",16.07
"Steel Cans",12.25
"PET (including forming)",12.12
"WEEE - Small",10.54
"WEEE - Mixed",9.77
"WEEE - Large",9.00
"PS (including forming)",8.81
"Wood",8.70
"Average Plastics",8.57
"Average plastic rigid (including bottles)",8.56
"HDPE (including forming)",8.25
"LDPE and LLDPE (including forming)",7.80
"Average plastic film (including bags)",7.65
"PP (including forming)",6.74
"PVC (including forming)",6.31
"Board",5.83
"Mixed paper and board",5.68
"Paper",5.23
"Books",5.23
"Mineral Oil",5.15
"WEEE - Fridges and Freezers",4.66
"Food and Drink Waste (wet AD)",4.35
"Food and Drink Waste (Composting)",3.48
"Batteries (Post Consumer Non Automotive)",3.46
"Glass (colour separated)",2.78
"Mixed Food and Garden Waste (dry AD)",2.70
"Garden Waste (dry AD)",2.35
"Mixed Food and Garden Waste (Composting)",2.10
"Garden Waste Composting",1.81
"Glass (mixed colours)",1.58
"Plasterboard",0.99
"Aggregates (Rubble)",0.03
```

enablers.csv

```
name,latitude,longitude
"Alloa Community Enterprises",56.122913,-3.781621
"Stirling Comunity Food",56.115672,-3.936217
"Stirling Council",56.113345,-3.936807
"The Fair Share",56.146389,-3.919833
```

Appendix B: Mapping files

ace-to-carbon-metric.csv

```
category,item,material
Furniture ,"Bedside unit, cabinet or table",Wood
Furniture ,"Bench, kitchen or garden, solid wood",Wood
Furniture ,"Blanket box, Ottoman",Wood
Furniture ,Bookcase / Shelving Unit,Wood
Furniture ,"Cabinet (display & kitchen), Bureau",Wood
Furniture ,"Chair, Kitchen, Dining or Wooden",Wood
Furniture ,"Chest-of-Drawers, Tallboy",Wood
Furniture ,"Small Desk, Computer Table",Wood
Furniture ,Large Desk,Wood
Furniture ,Dressing table ,Wood
Furniture ,Fire surround ,Wood
Furniture ,Grandfather clock ,Wood
Furniture ,Headboard unit (with built-in bedside cabinets) ,Wood
Furniture ,Headboard,Wood
Furniture ,TV / Hi-fi unit ,Wood
Furniture ,Piano,Wood
Furniture ,"Sideboard, not large ",Wood
Furniture ,"Table small eg. Cane, coffee, occassional, nest of ",Wood
Furniture ,"Table, large e.g. dining",Wood
Furniture ,"Table, medium e.g. kitchen",Wood
Furniture ,Wall unit,Wood
Furniture ,"Wardrobe, double ",Wood
Furniture ,"Wardrobe, single ",Wood
Furniture ,Welsh Dresser ,Wood
Home Office Furniture ,"Cabinet, large",Scrap Metal
Home Office Furniture ,"Filing cabinet, large ",Scrap Metal
Home Office Furniture ,"Cabinet or filing cabinet, small",Scrap Metal
Home Office Furniture ,Office Chair ,Wood
Home Office Furniture ,Office Desk ,Wood
Soft Furniture ,2 seater sofa,Textiles and Footwear
Soft Furniture ,3 seater sofa,Textiles and Footwear
Soft Furniture ,Armchair ,Textiles and Footwear
Soft Furniture ,Recliner,Textiles and Footwear
Soft Furniture ,"Bed, single complete (base, mattress + headboard) ",Textiles and
Footwear
Soft Furniture ,"Bed, double complete (base, mattress + headboard) ",Textiles and
Footwear
Soft Furniture ,"Bed, king-size complete (base, mattress + headboard) ",Textiles and
Footwear
Soft Furniture ,"Bed base, single wood / divan / folding / Z bed ",Wood
Soft Furniture ,"Bed base, double wood / divan / folding / Z bed ",Wood
Soft Furniture ,"Bed base, king-size wood, divan or double metal ",Wood
Soft Furniture ,Bunk bed / cabin bed ,Wood
Soft Furniture ,"Cane chair, bookcase",Wood
```

```
Soft Furniture ,"Chair, easy, fireside, lounge, rocking",Wood
Soft Furniture ,Chaise Longue ,Wood
Soft Furniture ,Futon / Sofabed (wooden base with mattress) ,Textiles and Footwear
Soft Furniture ,"Mattress, single ",Textiles and Footwear
Soft Furniture ,"Mattress, double ",Textiles and Footwear
Soft Furniture ,"Mattress, king-size ",Textiles and Footwear
Soft Furniture ,Pouffe / Stool,Textiles and Footwear
Soft Furniture ,"Sofa bed, foam flop out ",Textiles and Footwear
Soft Furniture ,"Sofa bed, metal frame ",Scrap Metal
Soft Furniture ,"Sofa, cane / conservatory (normally with cushions) ",Wood
Bric-a-Brac,Bric-a-Brac (small packet) ,Average Plastics
Bric-a-Brac,Bric-a-Brac (box) ,Scrap Metal
Children's Items,Cot ,Wood
Children's Items,High Chair,Wood
Children's Items,Pram,Scrap Metal
Children's Items,Pushchair,Scrap Metal
Children's Items,Stairgate,Average Plastics
Children's Items,"Toys, box",Average Plastics
Leisure,"Bike, adult",Scrap Metal
Leisure,"Bike, child",Scrap Metal
Miscellaneous,"Small misc, eg scales, saucepans, shoe racks, pedal bin, picture,
magazine rack, fireguard, CD stand, picture frame, curtain pole, lampshade, suitcase,
wine rack, Christmas tree",Wood
Miscellaneous,"Medium misc, eg tea trolley, ironing board, plant stand, coat or hat
stand, small mirror, clothes horse, ",Wood
Miscellaneous,"Large misc, eg carpet cleaner, large mirror, ladder, laundry basket,
loose shelves",Wood
Flooring,"Carpet tiles, lino,  carpet, flooring or underlay for standard room
12'x12'",Textiles and Footwear
Flooring,Small rug 3'x6',Textiles and Footwear
Bedding & window dressings,"Pillow, pillow case",Textiles
Bedding & window dressings,Sheet,Textiles
Bedding & window dressings,"Blanket, towel, throw, duvet cover",Textiles
Bedding & window dressings,"Blinds (fabric), light or mid weight curtains",Textiles
Bedding & window dressings,"Blinds (wood, metal), curtains (thick, lined)",Textiles
Bathroom Items ,Bath (metal) ,Scrap Metal
Bathroom Items ,Bath (non-metal) ,Average plastic rigid (including bottles)
Bathroom Items ,Bathroom Cabinet /Shower Screen,Average plastic rigid (including
bottles)
Bathroom Items ,Cistern ,Plasterboard
Bathroom Items ,Shower equipment/tray ,Plasterboard
Bathroom Items ,Sink (ceramic) ,Plasterboard
Bathroom Items ,Sink (metal) ,Scrap Metal
Bathroom Items ,Toilet ,Plasterboard
Bathroom Items ,"Vanity Unit, including sink ",Wood
DIY,Door (pvc),PVC (including forming)
DIY,Door (wood) ,Wood
DIY,Gate (metal) ,Scrap Metal
DIY,Gate (wood),Wood
DIY,Paint  (5l),Batteries (Post Consumer Non Automotive)
DIY,Patio door,PVC (including forming)
```

```
DIY,"Tiles (ceramic), per square metre",Plasterboard
DIY,Window (wood),Wood
DIY,Window (glazed),PVC (including forming)
DIY,Worktop (kitchen) ,Wood
Garden,BBQ,Scrap Metal
Garden,"Chair (metal, plastic or wood)",PVC (including forming)
Garden,Lounger ,PVC (including forming)
Garden,Rotary Drier ,Scrap Metal
Garden,"Table (metal, plastic or wood)",PVC (including forming)
Garden,"Tool (large) i.e. spade, fork",Scrap Metal
Garden,Tool (small) i.e. trowel,Scrap Metal
Garden,Waterbutt,PVC (including forming)
Garden,Wheelbarrow ,Scrap Metal
Gas Appliances,"Cooker, gas",WEEE - Large
Gas Appliances,"Hob, gas",WEEE - Large
Gas Appliances,"Fire, gas",WEEE - Large
Cat 1 - Large Household Appliances,"Baby belling, counter top cooker, hostess trolley
",WEEE - Large
Cat 1 - Large Household Appliances,Cooker hood,WEEE - Large
Cat 1 - Large Household Appliances,"Cooker, electric ",WEEE - Large
Cat 1 - Large Household Appliances,Dishwasher ,WEEE - Large
Cat 1 - Large Household Appliances,Spin-Dryer ,WEEE - Large
Cat 1 - Large Household Appliances,Tumble-Dryer ,WEEE - Large
Cat 1 - Large Household Appliances,Twin-tub ,WEEE - Large
Cat 1 - Large Household Appliances,Washer Drier,WEEE - Large
Cat 1 - Large Household Appliances,Washing Machine ,WEEE - Large
Cat 2 - Small Household Appliances,Electric sewing maching,WEEE - Small
Cat 2 - Small Household Appliances,Fan (electric) ,WEEE - Small
Cat 2 - Small Household Appliances,Fan heater,WEEE - Small
Cat 2 - Small Household Appliances,Fire,WEEE - Small
Cat 2 - Small Household Appliances,"Hair & Beauty Elec  i.e. hair dryer, foot
massager, hair curlers, hair straighteners",WEEE - Small
Cat 2 - Small Household Appliances,"Hob, electric",WEEE - Small
Cat 2 - Small Household Appliances,"Medium elec - bread machine, video camera, trouser
press",WEEE - Small
Cat 2 - Small Household Appliances,Microwave ,WEEE - Small
Cat 2 - Small Household Appliances,Radiator,WEEE - Small
Cat 2 - Small Household Appliances,"Small elec - kettle, toaster, clock, sandwich
maker,coffee maker, juicer, rice cooker ,steamer, iron, food mixer",WEEE - Small
Cat 2 - Small Household Appliances,Vacuum ,WEEE - Small
Cat 3 - IT & Telecommunications,"Computer, base unit",WEEE - Mixed
Cat 3 - IT & Telecommunications,Laptop,WEEE - Mixed
Cat 3 - IT & Telecommunications,"Mobile Phone & Accessories (hands free kit,
charger)",WEEE - Mixed
Cat 3 - IT & Telecommunications,"PC Accessories (keyboard, mouse)",WEEE - Mixed
Cat 3 - IT & Telecommunications,"PC Printers, Scanners, Shredder",WEEE - Mixed
Cat 3 - IT & Telecommunications,Photocopier ,WEEE - Mixed
Cat 3 - IT & Telecommunications,Telecommunications equipment,WEEE - Mixed
Cat 3 - IT & Telecommunications,"Wordprocessor, Electric Typewriter",WEEE - Mixed
Cat 4 - Consumer Equipment,"Hi-fi, integrated",WEEE - Mixed
Cat 4 - Consumer Equipment,"Hi-fi, separates (amplifier, cassette deck, CD player,
```

```
radio, speakers)",WEEE - Mixed
Cat 4 - Consumer Equipment,"Video, DVD, Games Consoles, Digiboxes",WEEE - Mixed
Cat 5 - Lighting Equipment,Lamp / Light,WEEE - Mixed
Cat 6 - Electrical & Electronic Tools,"Garden tools, electrical (small) i.e. strimmer,
hedge cutter, garden vac",WEEE - Mixed
Cat 6 - Electrical & Electronic Tools,"Garden tools, electrical (large) i.e.
lawnmower, shredder",WEEE - Mixed
Cat 6 - Electrical & Electronic Tools,"Power Tools i.e. drill, electric
screwdriver",WEEE - Mixed
"Cat 7 - Toys, leisure & sports","Musical Instruments i.e. keyboard, organ",WEEE -
Mixed
"Cat 7 - Toys, leisure & sports",Sunbed,WEEE - Large
Cat 8 - Medical devices,Electric Armchair,WEEE - Large
Cat 8 - Medical devices,"Electric Bed, double",WEEE - Large
Cat 8 - Medical devices,"Electric Bed, single",WEEE - Large
Cat 8 - Medical devices,Electric Wheelchair,WEEE - Large
Cat 11 - Display Equipment,"CRT-Monitor <14"" ",WEEE - Mixed
Cat 11 - Display Equipment,"CRT-Monitor 14"" ",WEEE - Mixed
Cat 11 - Display Equipment,"CRT-Monitor 15"" ",WEEE - Mixed
Cat 11 - Display Equipment,"CRT-Monitor 17"" ",WEEE - Mixed
Cat 11 - Display Equipment,"CRT-Monitor 19"" ",WEEE - Mixed
Cat 11 - Display Equipment,"CRT-Monitor 21"" ",WEEE - Mixed
Cat 11 - Display Equipment,TV Portable or TV Combi,WEEE - Mixed
Cat 11 - Display Equipment,"Flat screen display 15-17""",WEEE - Mixed
Cat 11 - Display Equipment,"Flat screen display 19-20""",WEEE - Mixed
Cat 11 - Display Equipment,"Flat screen display 22-24""",WEEE - Mixed
Cat 11 - Display Equipment,"Flat screen display 26-30""",WEEE - Mixed
Cat 11 - Display Equipment,"Flat screen display 32-37""",WEEE - Mixed
Cat 11 - Display Equipment,"Flat screen display 40-46""",WEEE - Mixed
Cat 12 - Cooling Appliances containing refrigeration,"Air Conditioner,
Dehumidifier",WEEE - Mixed
Cat 12 - Cooling Appliances containing refrigeration,"Freezer, chest ",WEEE - Fridges
and Freezers
Cat 12 - Cooling Appliances containing refrigeration,"Freezer, free standing",WEEE -
Fridges and Freezers
Cat 12 - Cooling Appliances containing refrigeration,"Freezer / Fridge, table
top",WEEE - Fridges and Freezers
Cat 12 - Cooling Appliances containing refrigeration,"Freezer, undercounter",WEEE -
Fridges and Freezers
Cat 12 - Cooling Appliances containing refrigeration,"Fridge, free standing",WEEE -
Fridges and Freezers
Cat 12 - Cooling Appliances containing refrigeration,"Fridge, undercounter",WEEE -
Fridges and Freezers
Cat 12 - Cooling Appliances containing refrigeration,Fridge-Freezer ,WEEE - Fridges
and Freezers
```

stirling-community-food-to-carbon-metric.csv

```
outcome,material
"human-food, bio-etc & sanctuary","Food and Drink Waste (wet AD)"
compost-indiv,"Food and Drink Waste (Composting)"
```

stirling-council-to-carbon-metric.csv

```
"Waste Collected",material
"02 Garden Waste","Mixed Food and Garden Waste (Composting)"
"105 Mixed Paper","Paper"
"106 Fibre (Paper & Card)","Mixed paper and board"
"107 Containers Stream","Average Plastics"
"108 Comingled Organic","Mixed Food and Garden Waste (dry AD)"
"17 Cardboard","Mixed paper and board"
"72 Mixed Glass","Glass (mixed colours)"
```

the-fair-share-to-carbon-metric.csv

```
"(The Fair Share's) Material",material
"Textiles & Footwear","Textiles & Footwear"
Books,Books
Aggregates,"Aggregates (Rubble)"
Glass,"Glass (mixed colours)"
"Food & Drink","Food and Drink Waste (wet AD)"
```

Appendix C: CSVW files

carbon-savings-metadata.json

```
{
  "@context": "http://www.w3.org/ns/csvw",
  "tableSchema": {
    "columns": [{
      "name": "occurrenceDate",
      "titles": "occurrence-date",
      "datatype": "date",
      "propertyUrl": "http://datacommonsscotland.org/linked-
data/property/hasOccurrenceDate"
    }, {
      "name": "material",
      "titles": "scottish-carbon-metric-material",
      "datatype": "string",
      "propertyUrl": "http://datacommonsscotland.org/linked-
data/property/hasMaterial",
      "valueUrl": "http://datacommonsscotland.org/linked-data/entity/carbon-
```

```
metric/{material}"
    }, {
      "name": "tonnesWeight",
      "titles": "tonnes-weight",
      "datatype": "decimal",
      "required": true,
      "propertyUrl": "http://datacommonsscotland.org/linked-
data/property/hasTonnesWeight"
    }, {
      "name": "enabler",
      "titles": "enabler",
      "datatype": "string",
      "propertyUrl": "http://datacommonsscotland.org/linked-data/property/hasEnabler",
      "valueUrl": "http://datacommonsscotland.org/linked-
data/entity/enablers/{enabler}"
    }, {
      "name": "enablerSpecific",
      "titles": "enabler-specific",
      "datatype": "string",
      "propertyUrl": "http://datacommonsscotland.org/linked-
data/property/hasEnablerSpecific"
    }, {
      "virtual": true,
      "propertyUrl": "http://www.w3.org/1999/02/22-rdf-syntax-ns#type",
      "valueUrl": "http://datacommonsscotland.org/linked-data/class/carbon-savings"
    }],
    "primaryKey": ["occurrenceDate", "material", "enabler", "enablerSpecific"],
    "foreignKeys": [{
      "columnReference": "material",
      "reference": {
        "resource": "carbon-metric.csv",
        "columnReference": "material"
      }
    }, {
      "columnReference": "enabler",
      "reference": {
        "resource": "enablers.csv",
        "columnReference": "name"
      }
    }],
    "aboutUrl": "http://datacommonsscotland.org/linked-data/entity/carbon-
savings/{occurrenceDate}/{material}/{enabler}/{enablerSpecific}"
  }
}
```


carbon-metric-metadata.json

```
{
  "@context": "http://www.w3.org/ns/csvw",
  "tableSchema": {
    "columns": [{
      "name": "material",
      "titles": "material",
      "datatype": "string",
      "propertyUrl": "http://datacommonsscotland.org/linked-data/property/hasMaterial"
    }, {
      "name": "multiplier",
      "titles": "multiplier",
      "datatype": "decimal",
      "required": true,
      "propertyUrl": "http://datacommonsscotland.org/linked-
data/property/hasMultiplier"
    }, {
      "virtual": true,
      "propertyUrl": "http://www.w3.org/1999/02/22-rdf-syntax-ns#type",
      "valueUrl": "http://datacommonsscotland.org/linked-data/class/carbon-metric"
    }],
    "primaryKey": "material",
    "aboutUrl": "http://datacommonsscotland.org/linked-data/entity/carbon-
metric/{material}"
  }
}
```

enablers-metadata.json

```
{
  "@context": "http://www.w3.org/ns/csvw",
  "tableSchema": {
    "columns": [{
      "name": "name",
      "titles": "name",
      "datatype": "string",
      "propertyUrl": "http://datacommonsscotland.org/linked-data/property/hasName"
    }, {
      "name": "latitude",
      "titles": "latitude",
      "datatype": "decimal",
      "propertyUrl": "http://datacommonsscotland.org/linked-data/property/hasLatitude"
    }, {
      "name": "longitude",
      "titles": "longitude",
      "datatype": "decimal",
      "propertyUrl": "http://datacommonsscotland.org/linked-
data/property/hasLongitude"
    }, {
      "virtual": true,
      "propertyUrl": "http://www.w3.org/1999/02/22-rdf-syntax-ns#type",
      "valueUrl": "http://datacommonsscotland.org/linked-data/class/enablers"
    }],
    "primaryKey": "name",
    "aboutUrl": "http://datacommonsscotland.org/linked-data/entity/enablers/{name}"
  }
}
```

Appendix D: RDF files

carbon-savings.ttl

```
<http://datacommonsscotland.org/linked-data/entity/carbon-savings/2018-02-
28/Wood/Alloa%20Community%20Enterprises/55%20items%20of%20Furniture%20%28Chair%2C%20Ki
tchen%2C%20Dining%20or%20Wooden%29>
  a <http://datacommonsscotland.org/linked-data/class/carbon-savings>;
  <http://datacommonsscotland.org/linked-data/property/hasEnabler>
<http://datacommonsscotland.org/linked-
data/entity/enablers/Alloa%20Community%20Enterprises>;
  <http://datacommonsscotland.org/linked-data/property/hasEnablerSpecific> "55 items
of Furniture (Chair, Kitchen, Dining or Wooden)";
  <http://datacommonsscotland.org/linked-data/property/hasMaterial>
<http://datacommonsscotland.org/linked-data/entity/carbon-metric/Wood>;
  <http://datacommonsscotland.org/linked-data/property/hasOccurrenceDate> "2018-02-
28"^^<http://www.w3.org/2001/XMLSchema#date>;
  <http://datacommonsscotland.org/linked-data/property/hasTonnesWeight> 0.385 .
```

```
<http://datacommonsscotland.org/linked-data/entity/carbon-savings/2018-02-
28/Wood/Alloa%20Community%20Enterprises/82%20items%20of%20Furniture%20%28Chair%2C%20Ki
tchen%2C%20Dining%20or%20Wooden%29>
  a <http://datacommonsscotland.org/linked-data/class/carbon-savings>;
  <http://datacommonsscotland.org/linked-data/property/hasEnabler>
<http://datacommonsscotland.org/linked-
data/entity/enablers/Alloa%20Community%20Enterprises>;
  <http://datacommonsscotland.org/linked-data/property/hasEnablerSpecific> "82 items
of Furniture (Chair, Kitchen, Dining or Wooden)";
  <http://datacommonsscotland.org/linked-data/property/hasMaterial>
<http://datacommonsscotland.org/linked-data/entity/carbon-metric/Wood>;
  <http://datacommonsscotland.org/linked-data/property/hasOccurrenceDate> "2018-02-
28"^^<http://www.w3.org/2001/XMLSchema#date>;
  <http://datacommonsscotland.org/linked-data/property/hasTonnesWeight> 0.574 .

<http://datacommonsscotland.org/linked-data/entity/carbon-savings/2019-02-
28/Textiles%20and%20Footwear/Alloa%20Community%20Enterprises/7%20items%20of%20Soft%20F
urniture%20%28Mattress%2C%20single%29>
  a <http://datacommonsscotland.org/linked-data/class/carbon-savings>;
  <http://datacommonsscotland.org/linked-data/property/hasEnabler>
<http://datacommonsscotland.org/linked-
data/entity/enablers/Alloa%20Community%20Enterprises>;
  <http://datacommonsscotland.org/linked-data/property/hasEnablerSpecific> "7 items of
Soft Furniture (Mattress, single)";
  <http://datacommonsscotland.org/linked-data/property/hasMaterial>
<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Textiles%20and%20Footwear>;
  <http://datacommonsscotland.org/linked-data/property/hasOccurrenceDate> "2019-02-
28"^^<http://www.w3.org/2001/XMLSchema#date>;
  <http://datacommonsscotland.org/linked-data/property/hasTonnesWeight> 0.147 .

<http://datacommonsscotland.org/linked-data/entity/carbon-savings/2019-02-
28/Textiles%20and%20Footwear/Alloa%20Community%20Enterprises/8%20items%20of%20Soft%20F
urniture%20%28Mattress%2C%20single%29>
  a <http://datacommonsscotland.org/linked-data/class/carbon-savings>;
  <http://datacommonsscotland.org/linked-data/property/hasEnabler>
<http://datacommonsscotland.org/linked-
data/entity/enablers/Alloa%20Community%20Enterprises>;
  <http://datacommonsscotland.org/linked-data/property/hasEnablerSpecific> "8 items of
Soft Furniture (Mattress, single)";
  <http://datacommonsscotland.org/linked-data/property/hasMaterial>
<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Textiles%20and%20Footwear>;
  <http://datacommonsscotland.org/linked-data/property/hasOccurrenceDate> "2019-02-
28"^^<http://www.w3.org/2001/XMLSchema#date>;
  <http://datacommonsscotland.org/linked-data/property/hasTonnesWeight> 0.168 .

<http://datacommonsscotland.org/linked-data/entity/carbon-savings/2021-01-
28/Food%20and%20Drink%20Waste%20%28wet%20AD%29/Stirling%20Comunity%20Food/Used%20for%2
0human-food%2C%20bio-etc%20%26%20sanctuary>
  a <http://datacommonsscotland.org/linked-data/class/carbon-savings>;
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  <http://datacommonsscotland.org/linked-data/property/hasEnabler>
<http://datacommonsscotland.org/linked-
data/entity/enablers/Stirling%20Comunity%20Food>;
  <http://datacommonsscotland.org/linked-data/property/hasEnablerSpecific> "Used for
human-food, bio-etc & sanctuary";
  <http://datacommonsscotland.org/linked-data/property/hasMaterial>
<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Food%20and%20Drink%20Waste%20%28wet%20AD%29>;
  <http://datacommonsscotland.org/linked-data/property/hasOccurrenceDate> "2021-01-
28"^^<http://www.w3.org/2001/XMLSchema#date>;
  <http://datacommonsscotland.org/linked-data/property/hasTonnesWeight> 0.08761 .

<http://datacommonsscotland.org/linked-data/entity/carbon-savings/2021-01-
28/Food%20and%20Drink%20Waste%20%28Composting%29/Stirling%20Comunity%20Food/Used%20for
%20compost-indiv>
  a <http://datacommonsscotland.org/linked-data/class/carbon-savings>;
  <http://datacommonsscotland.org/linked-data/property/hasEnabler>
<http://datacommonsscotland.org/linked-
data/entity/enablers/Stirling%20Comunity%20Food>;
  <http://datacommonsscotland.org/linked-data/property/hasEnablerSpecific> "Used for
compost-indiv";
  <http://datacommonsscotland.org/linked-data/property/hasMaterial>
<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Food%20and%20Drink%20Waste%20%28Composting%29>;
  <http://datacommonsscotland.org/linked-data/property/hasOccurrenceDate> "2021-01-
28"^^<http://www.w3.org/2001/XMLSchema#date>;
  <http://datacommonsscotland.org/linked-data/property/hasTonnesWeight> 0.00048 .

<http://datacommonsscotland.org/linked-data/entity/carbon-savings/2021-01-
29/Food%20and%20Drink%20Waste%20%28wet%20AD%29/Stirling%20Comunity%20Food/Used%20for%2
0human-food%2C%20bio-etc%20%26%20sanctuary>
  a <http://datacommonsscotland.org/linked-data/class/carbon-savings>;
  <http://datacommonsscotland.org/linked-data/property/hasEnabler>
<http://datacommonsscotland.org/linked-
data/entity/enablers/Stirling%20Comunity%20Food>;
  <http://datacommonsscotland.org/linked-data/property/hasEnablerSpecific> "Used for
human-food, bio-etc & sanctuary";
  <http://datacommonsscotland.org/linked-data/property/hasMaterial>
<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Food%20and%20Drink%20Waste%20%28wet%20AD%29>;
  <http://datacommonsscotland.org/linked-data/property/hasOccurrenceDate> "2021-01-
29"^^<http://www.w3.org/2001/XMLSchema#date>;
  <http://datacommonsscotland.org/linked-data/property/hasTonnesWeight> 0.28012 .

<http://datacommonsscotland.org/linked-data/entity/carbon-savings/2021-01-
29/Food%20and%20Drink%20Waste%20%28Composting%29/Stirling%20Comunity%20Food/Used%20for
%20compost-indiv>
  a <http://datacommonsscotland.org/linked-data/class/carbon-savings>;
  <http://datacommonsscotland.org/linked-data/property/hasEnabler>
<http://datacommonsscotland.org/linked-
data/entity/enablers/Stirling%20Comunity%20Food>;
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  <http://datacommonsscotland.org/linked-data/property/hasEnablerSpecific> "Used for
compost-indiv";
  <http://datacommonsscotland.org/linked-data/property/hasMaterial>
<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Food%20and%20Drink%20Waste%20%28Composting%29>;
  <http://datacommonsscotland.org/linked-data/property/hasOccurrenceDate> "2021-01-
29"^^<http://www.w3.org/2001/XMLSchema#date>;
  <http://datacommonsscotland.org/linked-data/property/hasTonnesWeight> 0.008 .

<http://datacommonsscotland.org/linked-data/entity/carbon-savings/2021-01-
03/Glass%20%28mixed%20colours%29/Stirling%20Council/Balfron>
  a <http://datacommonsscotland.org/linked-data/class/carbon-savings>;
  <http://datacommonsscotland.org/linked-data/property/hasEnabler>
<http://datacommonsscotland.org/linked-data/entity/enablers/Stirling%20Council>;
  <http://datacommonsscotland.org/linked-data/property/hasEnablerSpecific> "Balfron";
  <http://datacommonsscotland.org/linked-data/property/hasMaterial>
<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Glass%20%28mixed%20colours%29>;
  <http://datacommonsscotland.org/linked-data/property/hasOccurrenceDate> "2021-01-
03"^^<http://www.w3.org/2001/XMLSchema#date>;
  <http://datacommonsscotland.org/linked-data/property/hasTonnesWeight> 3.5 .

<http://datacommonsscotland.org/linked-data/entity/carbon-savings/2021-01-
04/Average%20Plastics/Stirling%20Council/Bridge%20of%20Allan>
  a <http://datacommonsscotland.org/linked-data/class/carbon-savings>;
  <http://datacommonsscotland.org/linked-data/property/hasEnabler>
<http://datacommonsscotland.org/linked-data/entity/enablers/Stirling%20Council>;
  <http://datacommonsscotland.org/linked-data/property/hasEnablerSpecific> "Bridge of
Allan";
  <http://datacommonsscotland.org/linked-data/property/hasMaterial>
<http://datacommonsscotland.org/linked-data/entity/carbon-metric/Average%20Plastics>;
  <http://datacommonsscotland.org/linked-data/property/hasOccurrenceDate> "2021-01-
04"^^<http://www.w3.org/2001/XMLSchema#date>;
  <http://datacommonsscotland.org/linked-data/property/hasTonnesWeight> 1.86 .

<http://datacommonsscotland.org/linked-data/entity/carbon-savings/2021-01-
10/Mixed%20paper%20and%20board/Stirling%20Council/Killearn>
  a <http://datacommonsscotland.org/linked-data/class/carbon-savings>;
  <http://datacommonsscotland.org/linked-data/property/hasEnabler>
<http://datacommonsscotland.org/linked-data/entity/enablers/Stirling%20Council>;
  <http://datacommonsscotland.org/linked-data/property/hasEnablerSpecific> "Killearn";
  <http://datacommonsscotland.org/linked-data/property/hasMaterial>
<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Mixed%20paper%20and%20board>;
  <http://datacommonsscotland.org/linked-data/property/hasOccurrenceDate> "2021-01-
10"^^<http://www.w3.org/2001/XMLSchema#date>;
  <http://datacommonsscotland.org/linked-data/property/hasTonnesWeight> 0.24 .

<http://datacommonsscotland.org/linked-data/entity/carbon-savings/2019-12-
31/Textiles%20%26%20Footwear/The%20Fair%20Share/autumn%20semester>
  a <http://datacommonsscotland.org/linked-data/class/carbon-savings>;
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  <http://datacommonsscotland.org/linked-data/property/hasEnabler>
<http://datacommonsscotland.org/linked-data/entity/enablers/The%20Fair%20Share>;
  <http://datacommonsscotland.org/linked-data/property/hasEnablerSpecific> "autumn
semester";
  <http://datacommonsscotland.org/linked-data/property/hasMaterial>
<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Textiles%20%26%20Footwear>;
  <http://datacommonsscotland.org/linked-data/property/hasOccurrenceDate> "2019-12-
31"^^<http://www.w3.org/2001/XMLSchema#date>;
  <http://datacommonsscotland.org/linked-data/property/hasTonnesWeight> 0.57644 .

<http://datacommonsscotland.org/linked-data/entity/carbon-savings/2019-12-
31/Books/The%20Fair%20Share/autumn%20semester>
  a <http://datacommonsscotland.org/linked-data/class/carbon-savings>;
  <http://datacommonsscotland.org/linked-data/property/hasEnabler>
<http://datacommonsscotland.org/linked-data/entity/enablers/The%20Fair%20Share>;
  <http://datacommonsscotland.org/linked-data/property/hasEnablerSpecific> "autumn
semester";
  <http://datacommonsscotland.org/linked-data/property/hasMaterial>
<http://datacommonsscotland.org/linked-data/entity/carbon-metric/Books>;
  <http://datacommonsscotland.org/linked-data/property/hasOccurrenceDate> "2019-12-
31"^^<http://www.w3.org/2001/XMLSchema#date>;
  <http://datacommonsscotland.org/linked-data/property/hasTonnesWeight> 0.12203 .

<http://datacommonsscotland.org/linked-data/entity/carbon-savings/2019-12-
31/Aggregates%20%28Rubble%29/The%20Fair%20Share/autumn%20semester>
  a <http://datacommonsscotland.org/linked-data/class/carbon-savings>;
  <http://datacommonsscotland.org/linked-data/property/hasEnabler>
<http://datacommonsscotland.org/linked-data/entity/enablers/The%20Fair%20Share>;
  <http://datacommonsscotland.org/linked-data/property/hasEnablerSpecific> "autumn
semester";
  <http://datacommonsscotland.org/linked-data/property/hasMaterial>
<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Aggregates%20%28Rubble%29>;
  <http://datacommonsscotland.org/linked-data/property/hasOccurrenceDate> "2019-12-
31"^^<http://www.w3.org/2001/XMLSchema#date>;
  <http://datacommonsscotland.org/linked-data/property/hasTonnesWeight> 0.05345 .

<http://datacommonsscotland.org/linked-data/entity/carbon-savings/2019-12-
31/Glass%20%28mixed%20colours%29/The%20Fair%20Share/autumn%20semester>
  a <http://datacommonsscotland.org/linked-data/class/carbon-savings>;
  <http://datacommonsscotland.org/linked-data/property/hasEnabler>
<http://datacommonsscotland.org/linked-data/entity/enablers/The%20Fair%20Share>;
  <http://datacommonsscotland.org/linked-data/property/hasEnablerSpecific> "autumn
semester";
  <http://datacommonsscotland.org/linked-data/property/hasMaterial>
<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Glass%20%28mixed%20colours%29>;
  <http://datacommonsscotland.org/linked-data/property/hasOccurrenceDate> "2019-12-
31"^^<http://www.w3.org/2001/XMLSchema#date>;
  <http://datacommonsscotland.org/linked-data/property/hasTonnesWeight> 0.02328 .
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<http://datacommonsscotland.org/linked-data/entity/carbon-savings/2019-12-
31/Food%20and%20Drink%20Waste%20%28wet%20AD%29/The%20Fair%20Share/autumn%20semester>
  a <http://datacommonsscotland.org/linked-data/class/carbon-savings>;
  <http://datacommonsscotland.org/linked-data/property/hasEnabler>
<http://datacommonsscotland.org/linked-data/entity/enablers/The%20Fair%20Share>;
  <http://datacommonsscotland.org/linked-data/property/hasEnablerSpecific> "autumn
semester";
  <http://datacommonsscotland.org/linked-data/property/hasMaterial>
<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Food%20and%20Drink%20Waste%20%28wet%20AD%29>;
  <http://datacommonsscotland.org/linked-data/property/hasOccurrenceDate> "2019-12-
31"^^<http://www.w3.org/2001/XMLSchema#date>;
  <http://datacommonsscotland.org/linked-data/property/hasTonnesWeight> 0.0187 .
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carbon-metric.ttl

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<http://datacommonsscotland.org/linked-data/entity/carbon-metric/Textiles> a
<http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Textiles";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 100.0 .

<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Textiles%20and%20Footwear>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Textiles and
Footwear";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 84.7 .

<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Aluminium%20cans%20and%20foil>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Aluminium cans
and foil";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 65.87 .

<http://datacommonsscotland.org/linked-data/entity/carbon-metric/Footwear> a
<http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Footwear";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 31.17 .

<http://datacommonsscotland.org/linked-data/entity/carbon-metric/Mixed%20Cans> a
<http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Mixed Cans";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 27.8 .

<http://datacommonsscotland.org/linked-data/entity/carbon-metric/Scrap%20Metal> a
    <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Scrap Metal";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 16.07 .
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<http://datacommonsscotland.org/linked-data/entity/carbon-metric/Steel%20Cans> a
<http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Steel Cans";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 12.25 .

<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/PET%20%28including%20forming%29>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "PET (including
forming)";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 12.12 .

<http://datacommonsscotland.org/linked-data/entity/carbon-metric/WEEE%20-%20Small>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "WEEE - Small";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 10.54 .

<http://datacommonsscotland.org/linked-data/entity/carbon-metric/WEEE%20-%20Mixed>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "WEEE - Mixed";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 9.77 .

<http://datacommonsscotland.org/linked-data/entity/carbon-metric/WEEE%20-%20Large>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "WEEE - Large";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 9.0 .

<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/PS%20%28including%20forming%29>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "PS (including
forming)";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 8.81 .

<http://datacommonsscotland.org/linked-data/entity/carbon-metric/Wood> a
<http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Wood";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 8.7 .

<http://datacommonsscotland.org/linked-data/entity/carbon-metric/Average%20Plastics>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Average
Plastics";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 8.57 .

<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Average%20plastic%20rigid%20%28including%20bottles%29>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Average plastic
rigid (including bottles)";
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  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 8.56 .

<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/HDPE%20%28including%20forming%29>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "HDPE (including
forming)";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 8.25 .

<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/LDPE%20and%20LLDPE%20%28including%20forming%29>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "LDPE and LLDPE
(including forming)";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 7.8 .

<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Average%20plastic%20film%20%28including%20bags%29>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Average plastic
film (including bags)";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 7.65 .

<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/PP%20%28including%20forming%29>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "PP (including
forming)";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 6.74 .

<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/PVC%20%28including%20forming%29>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "PVC (including
forming)";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 6.31 .

<http://datacommonsscotland.org/linked-data/entity/carbon-metric/Board> a
<http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Board";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 5.83 .

<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Mixed%20paper%20and%20board>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Mixed paper and
board";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 5.68 .

<http://datacommonsscotland.org/linked-data/entity/carbon-metric/Paper> a
<http://datacommonsscotland.org/linked-data/class/carbon-metric>;
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  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Paper";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 5.23 .

<http://datacommonsscotland.org/linked-data/entity/carbon-metric/Books> a
<http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Books";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 5.23 .

<http://datacommonsscotland.org/linked-data/entity/carbon-metric/Mineral%20Oil> a
    <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Mineral Oil";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 5.15 .

<http://datacommonsscotland.org/linked-data/entity/carbon-metric/WEEE%20-
%20Fridges%20and%20Freezers>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "WEEE - Fridges
and Freezers";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 4.66 .

<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Food%20and%20Drink%20Waste%20%28wet%20AD%29>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Food and Drink
Waste (wet AD)";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 4.35 .

<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Food%20and%20Drink%20Waste%20%28Composting%29>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Food and Drink
Waste (Composting)";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 3.48 .

<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Batteries%20%28Post%20Consumer%20Non%20Automotive%29>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Batteries (Post
Consumer Non Automotive)";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 3.46 .

<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Glass%20%28colour%20separated%29>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Glass (colour
separated)";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 2.78 .

<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Mixed%20Food%20and%20Garden%20Waste%20%28dry%20AD%29>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
```

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  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Mixed Food and
Garden Waste (dry AD)";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 2.7 .

<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Garden%20Waste%20%28dry%20AD%29>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Garden Waste (dry
AD)";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 2.35 .

<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Mixed%20Food%20and%20Garden%20Waste%20%28Composting%29>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Mixed Food and
Garden Waste (Composting)";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 2.1 .

<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Garden%20Waste%20Composting>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Garden Waste
Composting";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 1.81 .

<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Glass%20%28mixed%20colours%29>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Glass (mixed
colours)";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 1.58 .

<http://datacommonsscotland.org/linked-data/entity/carbon-metric/Plasterboard> a
<http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Plasterboard";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 0.99 .

<http://datacommonsscotland.org/linked-data/entity/carbon-
metric/Aggregates%20%28Rubble%29>
  a <http://datacommonsscotland.org/linked-data/class/carbon-metric>;
  <http://datacommonsscotland.org/linked-data/property/hasMaterial> "Aggregates
(Rubble)";
  <http://datacommonsscotland.org/linked-data/property/hasMultiplier> 0.03 .
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enablers.ttl

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<http://datacommonsscotland.org/linked-
data/entity/enablers/Alloa%20Community%20Enterprises>
  a <http://datacommonsscotland.org/linked-data/class/enablers>;
  <http://datacommonsscotland.org/linked-data/property/hasLatitude> 56.122913;
  <http://datacommonsscotland.org/linked-data/property/hasLongitude> -3.781621;
  <http://datacommonsscotland.org/linked-data/property/hasName> "Alloa Community
Enterprises" .

<http://datacommonsscotland.org/linked-
data/entity/enablers/Stirling%20Comunity%20Food>
  a <http://datacommonsscotland.org/linked-data/class/enablers>;
  <http://datacommonsscotland.org/linked-data/property/hasLatitude> 56.115672;
  <http://datacommonsscotland.org/linked-data/property/hasLongitude> -3.936217;
  <http://datacommonsscotland.org/linked-data/property/hasName> "Stirling Comunity
Food" .

<http://datacommonsscotland.org/linked-data/entity/enablers/Stirling%20Council> a
    <http://datacommonsscotland.org/linked-data/class/enablers>;
  <http://datacommonsscotland.org/linked-data/property/hasLatitude> 56.113345;
  <http://datacommonsscotland.org/linked-data/property/hasLongitude> -3.936807;
  <http://datacommonsscotland.org/linked-data/property/hasName> "Stirling Council" .

<http://datacommonsscotland.org/linked-data/entity/enablers/The%20Fair%20Share> a
    <http://datacommonsscotland.org/linked-data/class/enablers>;
  <http://datacommonsscotland.org/linked-data/property/hasLatitude> 56.146389;
  <http://datacommonsscotland.org/linked-data/property/hasLongitude> -3.919833;
  <http://datacommonsscotland.org/linked-data/property/hasName> "The Fair Share" .
```