Research report on carbon-based methodologies used by Libraries of Things (LoT)

*Figure SEQ Figure * ARABIC 1: Photo of the Crystal Palace Library of Things in London, sourced from https://www.libraryofthings.co.uk/crystalpalace/*

Table of Contents

With thanks to

Robert Stitelmann, La Manivelle

Jed Aitchison, Buy Nowt Leeds

Thobias, Returkultur

Nikolai Wolfert, Leila Berlin

Terence Finnegan, Edinburgh Tool Library

Alan Dalgairns, LendEngine

Executive Summary

This report has been commissioned by Benthyg Cymru with the primary objective of identifying and recommending a methodology to be used to calculate the carbon emissions savings that are a result of Benthyg Cymru's activities. Library of Things (LoT, hereafter) are organisations that lend items with the aim of encouraging borrowing rather than purchasing practices. One of the benefits of LoTs is that they reduce the amount of material goods required to be produced for a set population, by facilitating practices of use rather than ownership of material goods. This has a positive environmental impact, and one of the common ways to quantify that impact is by calculating the impact using carbon emissions as a metric.

In the production, transport, use and wasting of every material and product, carbon is emitted into the atmosphere and contributes to the greenhouse gas effect that increases the extent of planetary climate change. Carbon accounting, the process of calculating the emitted carbon of a process, product or service, allows individuals or organisations to quantify the environment impact their actions have. Given that the premise of LoTs is that every item borrowed is an item that was not purchased, carbon accounting on the environmental impact of LoTs is primarily concerned with the product inventory, not the transport/utilities/heating emissions from the operation of an LoT.

This report will provide a review of existing carbon methodologies used by LoTs and will recommend a methodology that can be used across Benthyg Cymru network of members with the available resources. As a secondary aim, it will also highlight how social and financial value are represented by other LoTs through available metrics. This report is structured around 6 LoTs with each displayed as a case study, which provides context, a detailed account of their carbon methodology and the benefits and limitations associated with this approach. This report will conclude with recommendations for future research into quantifying impact through metrics and general observations on how LoTs could collaborate to apply carbon methodologies and learn from one another. The research methodology of this report, further detail about the research brief and information on the libraries who were contacted and participated is available both within the body of the report and in the Appendix.

Methodology

This research was conducted over the course of one month, from February 7th to March 7th 2022. The primary aim of this research was to review the carbon emissions methodologies used by other LoTs/sharing initiatives, and to recommend a methodology to Benthyg Cymru that can be used across their member network. The research brief, attached on page , highlights three areas of research interest. Given the timeframe of this project, this report focuses on the primary aim of environmental impact metrics, but refers to the categories of social and economic value in the Future research section. Within environmental impact, there are a number of metrics that could be used, but this research focuses on carbon emissions savings as they are a commonly used metric within environmental impact research and can be clearly quantified in the context of a LoT.

The first stage was a thematic review of relevant literature, which was predominantly focused on reviewing available information on methodologies used for carbon accounting and the data variables they use. A contact list of LoTs was made to begin the interviewing process, adapted from a list provided by Benthyg Cymru. Many of the listed LoTs were found using a library map generated by the software platform MyTurn. The contact list was further developed using recommendations made by LoT contacts. The list originally focused on organisations based in the UK, as per the research brief, but was later expanded to include LoTs globally. There were certain challenges at this stage as some of the entries had incorrect or no contact information and some libraries had ceased operations. All suitable contacts were sent an email requesting their input for this research, and those who measured carbon emission savings and were available were scheduled for interviews. Further details on libraries contacted can be found in Appendix C.

The following page shows a map of the libraries that were contacted, and those included in this research as case studies. The interviews conducted were semi-structured, where the structure was provided by the five core questions, found in Appendix B, but allowing for further information or themes to emerge during the conversation. Most interviews were recorded for the sake of confirming details in the write-up stage. All participants were informed of and consented to this, as well as the use of their names and the names of their organisations within this report. An interview was also conducted with a member of LendEngine to confirm how the software's features could be used to measure carbon emissions and how inputs could be recorded within the system.

This report was compiled using information gathered during interviews, as well as using public data from LoT websites, news articles, the MyTurn LoT map and from publicly available LoT impact reports. Unless consent was explicitly given, the names of organisations and funders have been anonymised.

Case study locations

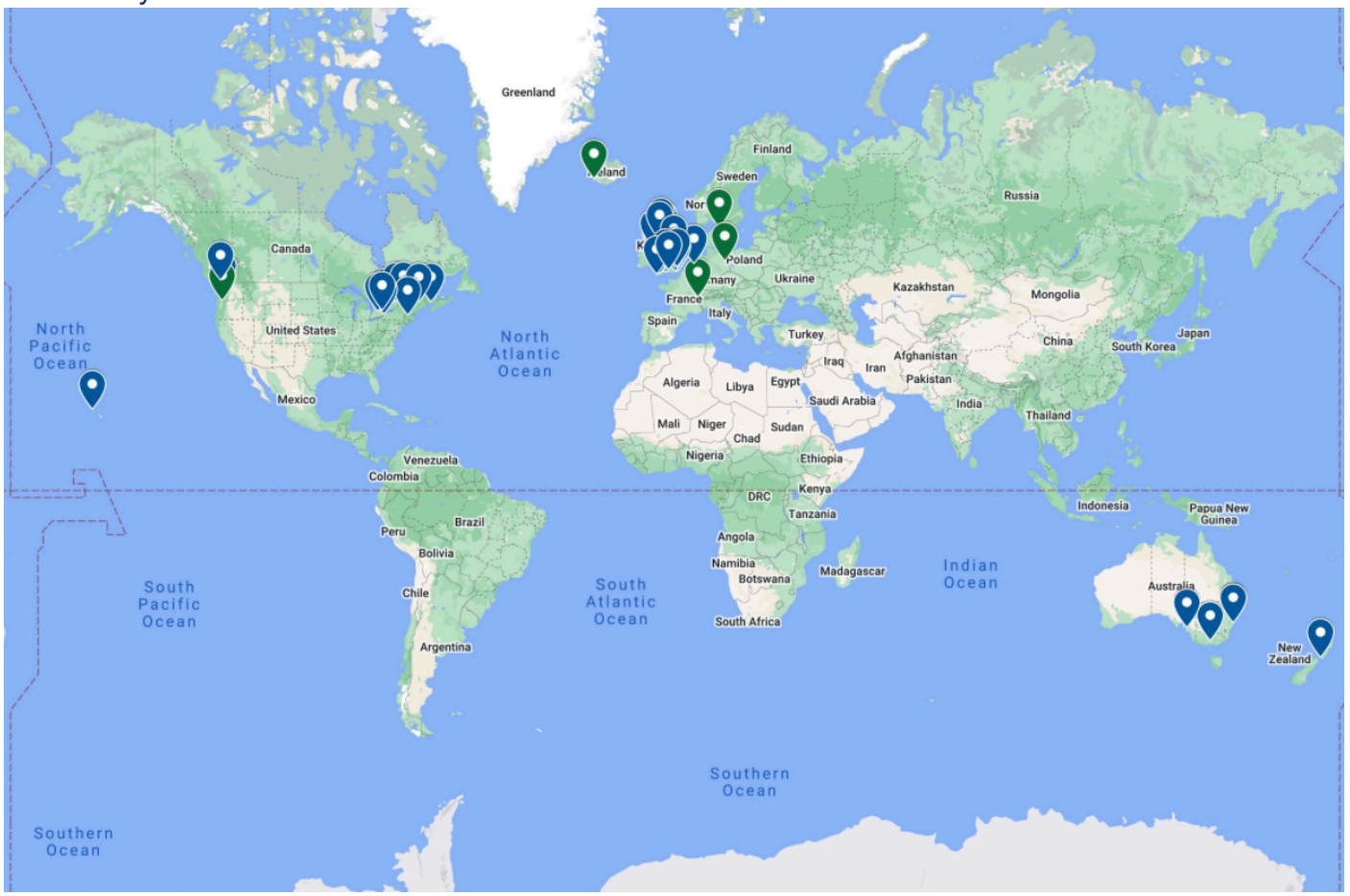

Figure 2; Map created of the 45 LoTs contacted during this research process, and the area they are located in listed below

- Salisbury
- Cornwall
- Essex
- Bristol
- Kingston upon Hull
- Glasgow
- Frome
- Bath
- Oxford
- Plymouth
- Devon

- London
- Crieff
- Edinburgh
- Lewes
- Leeds
- Guildford
- Weymouth
- Hastings
- Belfast
- Adelaide
- Vancouver

- Toronto
- Kitchener
- Buffalo
- Stirling
- Utrecht
- Berlin
- Geneva
- Gothenburg
- Reykjavík
- Northfield
- Glasgow 2

- Maine
- Saint John
- Montreal
- Ottawa
- Peterborough
- Melbourne
- Inner West
- Sydney
- Wellington
- Honolulu
- Tacoma
- Portland

Carbon emissions methodologies

The following case studies will use information on participating libraries to explore how and why carbon methodologies are used in their operations. These methodologies are all based upon the concept of *avoided emissions*, that the act of lending an item has the direct impact of avoiding carbon emissions that would have been generated had the user chosen to purchase that item new instead.

Library	Location	Time calculating carbon emissions
La Manivelle	Switzerland	1 year
Buy Nowt Leeds	United Kingdom	4 months
Returkultur	Sweden	1 year
Leila Berlin	Germany	-
Edinburgh Tool Library	United Kingdom	1 year
North Portland Tool Library	United States	1 year

Each case study is divided into three sections. The first contains contextual information about the library, its location, operational structure and membership system. The second details the carbon methodology in use – focusing on the primary objective that prompting the library to measure carbon emissions, what data metrics it records and how they are used, the carbon database used, and the equation used to produce the final carbon emissions data. The final section explores the advantages and limitations of using that methodology, concluded with a brief summary textbox.

Figure 3; Table of LoT case studies included in this report, and the approximate timeframe in which they measured carbon emissions

La Manivelle, Geneva

Context

La Manivelle is a cooperative non-profit LoT that was founded in July 2018 and is based in Switzerland. Currently, there are approximately 500 members who can visit one of 5 locations within the city of Geneva. La Manivelle aims to 'lend anything that can be shared' and to be used as much as possible by their members. They have a monthly and annual membership option for users, and pricing is structured in tiers to accommodate for those with 'modest means' (La Manivelle 2021). This year, La Manivelle was able to participate in a carbon emissions reduction initiative organised by a semi-state services provider. This initiative fits in to climate commitments established by the canton to reduce GHG emissions by 60% by 2030 and to become carbon neutral by 2050 (Ville de Geneve 2021). The initiative assisted environmental organisations to establish the carbon savings their products or services had accumulated in the course of a year.

Methodology

La Manivelle have tracked their carbon emissions savings using a year of data from 2021. The model they used was provided by an environmental consultancy firm and it calculated that in 2021, the library loaned from an inventory of 3000 items, there were approximately 5500 loans and there were 50 tonnes of avoided CO^2 emissions. The model for LCA was provided to La Manivelle as a spreadsheet with categories that organised common consumer goods based on their material composition in percentages. La Manivelle then had to weigh each item in their library inventory and assign them a category. Items had to be further divided into electronic and non-electronic lists, as there were different calculations used for each. The material composition and weight figures were inputs used to assign each item a carbon emission factor (CEF) that was logged on the MyTurn database. The final figure of carbon emissions saved was calculated by excluding second or subsequent loans of an item and adding up the CEF of each loaned item.

Benefits and Limitations

The LCA-based methodology applied at La Manivelle is very similar to the one applied at the Edinburgh Tool Library, except it has been adjusted to include categories for items other than tools. The benefits of this model are that apart from an initial investment of time and labour, the emission factors established for most goods will remain constant and are automatically logged for future carbon emissions tracking. The LCA approach can also be adapted overtime to produce new item categories based on changing material composition of consumer goods. It is currently unclear how different the equations for electronic items are, as the addition of batteries alters the environmental impact. Also, this trial phase excluded library items that were financially valued at less than 10 francs (£8.12) so depending on library inventory, this method could omit data on lower-cost items.

From what information is available about this LCA methodology, it appears to be a useful and sustainable approach for calculating emissions saving but requires significant initial investment to log and categorise each item, and the methodology is not publicly available

Buy Nowt, Leeds Library of Things

Context

Buy Nowt Leeds is a LoT based in Headingley, Leeds that began operating in 2020 during the Covid-19 pandemic. They have an active membership of 580 users and offer a range of subscription options, based on a pay-as-you-feel model. Buy Nowt LoT have begun tracking carbon emissions as wish to use it in their publicity and as a tangible metric that highlights the impact of their library. Within 4 months of opening, they have recorded 289 item loans.

Methodology

The emissions savings of Buy Nowt Leeds have been calculated through the use of an open-access carbon footprint calculator from Carbon Footprint™, which provides calculators for individuals and businesses to use (Carbon Footprint 2020). The calculator is using data from the UK Government's database of 'Greenhouse Gas Reporting: Conversion Factors 2021' (UK Government 2021). It is an important distinction to note that this calculator uses emissions factors that account for all primary GHGs, such as methane and nitrous oxide, and therefore, the resulting units of measurement are metric tonnes of CO^2 equivalent (CO^2e). This produces results that are slightly higher than in methodologies that are solely calculating CO^2. This process was calculated using the Secondary Footprint section of the calculator, that relates to 'emissions caused by manufacture, delivery and disposal of products and services' (Carbon Footprint 2020). This method requires the user to assign a financial value to each product or service they have used within the established timeframe (default 12 months). The consumption factors used are sourced from the UK Government document 'Annual greenhouse gas and carbon dioxide emissions relating to UK consumption', using data collected by the University of Leeds (DEFRA 2021). Buy Nowt Leeds used this methodology by estimating the value of every item in their inventory and combining them to produce an average monetary value for items. In this case, the average item value was just under 20£. This figure was then multiplied by the number of loans, excluding secondary/subsequent loans of the same item or extended loans.

$$sum\ of\ financial\ values\ of\ each\ item \div number\ of\ items\ =\ average\ item\ value$$

$$average\ item\ value\ x\ (number\ of\ loans\ -\ \ repeat\ or\ extended\ loans) = overall\ financial\ savings$$

$$overall\ financial\ savings \div 10\ =\ tonnes\ of\ carbon\ savings$$

Benefits and Limitations

This approach is a useful prototype to apply when beginning the process of carbon accounting for LoTs. The software it uses is intuitive and includes a broad range of item categories to use, so would be appropriate for a wide range of LoTs and sharing organisations. It is also regionally specific, as it uses carbon data from the UK government that appears to be updated regularly. This dataset is a good selection for UK-based LoTs as it would contain the most geographically relevant carbon data. However, it is somewhat limited by its use of a financial metric for the value of items. As many LoTs receive items that are donated/second-hand, it might be challenging and inaccurate to assign certain items a financial value. The categories used by the calculator are broad, which means the individual avoided emissions of each item is obscured. It is also unclear how the financial value relates to carbon emissions, whether this is referring to production, use, transport, waste or a combination.

This is a good basic methodology that can be used as an introduction the practice of carbon accounting, but would require significant development in order to become a more accurate carbon accountancy tool.

Returkultur, Gothenburg

Context

Returkultur is a non-profit association and sharing network based in the Västra Götaland region of Gothenburg, Sweden. It is focused on promoting recycling, sharing and environmentalism that relate to the arts and culture sphere. As such, many of the items available in their ‘lending pool’ are stage technology, props and musical equipment. However, they also have a wide range of home goods available to lend. Returkultur accept donations from both individuals and organisations, including broken items that can then be repaired in an educational workshop setting. The organisation has recently altered it’s membership scheme, so users purchase an annual membership, either at a standard rate of 1500SEK (115£) or 500SEK (38£) for those with limited or no income.

Methodology

Returkultur calculated their carbon emissions savings over the course of 12 months, focusing on the materials collected for the library inventory, rather than the emissions saved from the sharing process. When collecting the donated items, the Returkultur member would establish whether the items would have been disposed of or not. Using this information, they compiled an item list of items saved from landfill or incineration. The carbon data they used came from a Swedish

environmental research institute and the report ‘Climate Impact from Different Waste Fractions’ (translated title) (IVL: Swedish Environmental Science Institute 2019). Their report used a combination of their own data, data available from literature and expert assessments. This report methodology uses an accounting LCA approach, which generates average data figures for the production, materials and energy used in the creation of a product. This method also has calculated CO^2e using an IPCC 2013 methodology (IPCC 2013). This model defines waste prevention as reduced consumption or ‘avoided emissions’ – by borrowing one item, you are saving the emissions that would have occurred had you bought a new one. This approach did not define waste prevention through reusing products, with the exception of textiles (IVL: Swedish Environmental Science Institute 2019; 13). Using a series of regional and national data sources, IVL have produced two detailed tables of emissions figures, one based on material composition percentages (‘metal, aluminium (60% virgin, 40% recycled’) and one based on product type (‘power drill’). They have also compared the emissions from prevention (avoided emissions) to the emissions that would come from the recycling/treatment process of the same object/material. The Returkultur team used the data specific to the waste prevention from electronics reuse, while acknowledging there is a wide range of CO^2 savings figures for reusing electronics compared to recycling them. They calculated an estimated 190.7 tonnes of carbon savings within one year.

Benefits and Limitations

The benefits of this approach is it is based upon a comprehensive and well-designed accounting-LCA approach. It accounts for each stage of the material lifecycle and a significant body of regional carbon data. It also is unique in comparing the carbon emissions of prevention (lending) to the processes of recycling and waste management that the items would otherwise be processed through. The categories provided also allow users to divide their items using either by their material composition, or by product type, which makes it an adaptable for use across a range of libraries. However, this approach is based upon a vast field of carbon data specific to Sweden, and it’s successful use here in the UK would be reliant on access to and analysis of waste management/processing data for the model to be usable. Furthermore, this approach acknowledges the challenges in accurately accounting for electronic devices, as one category is for ‘miscellaneous electronics’

This is a comprehensive and quantitative approach to accounting for carbon emissions savings. However, it relies on datasets that are not immediately available in this context and are geographically specific.

Leila Berlin

Context

Leila is Berlin's first rental shop, first opened in 2010 and has been operating in a number of locations across the city since then. Leila operates in two spheres, a physical borrowing 'store' in Alexanderplatz, and through an online borrowing platform. There are approximately 200 items available in the Leila store, available to borrow free of charge provided the user brings an item to contribute to the store inventory. The online platform has 300 items available to 250 active users, with a peer-to-peer lending model encouraged. Leila also facilitates the introduction of 'sharing hubs' within Berlin residential areas, where users can set up smaller sharing operations.

Methodology

Leila received additional funding from a state body in 2018 that facilitated the further development of their operations, including developing their online sharing platform. With this opportunity, they wished to develop a prototype of a CO^2 emissions calculator, with the primary aim of highlighting to consumers the tangible environmental impact of borrowing over purchasing new items. It must be noted this calculator is in its first stages of development and is not a completed methodology yet. Leila is a part of the National Climate Protection Initiative and is currently involved with Berlin's plans to become a zero-waste capital city (Zero Waste Berlin 2022).

The carbon emissions calculations are made using two variables, the item category and the length of time the item was borrowed for. The carbon calculator used at this stage was provided by a prominent government-funded climate research institute in Germany. The lending system at Leila on the online platform is managed via an app, through which the exact length of time an item has been borrowed for is recorded. The current emissions prototype is based on the premise that each item has the same impact, and the number of days an item is in use is the primary measurable in the calculation. Using the user information collected online, the carbon emissions methodology is as follows:

$$Number\ of\ borrowing\ days\ x\ 1g\ of\ CO2e\ =\ carbon\ emissions\ saved\ per\ item$$

Benefits and Limitations

As a prototype, this method allows users of the library to internalise the connection between the act of borrowing and reduction of CO^2 emissions. On the app, Leila users can see their personal CO^2 emissions reduction to date as well as the collective emissions that come from all users of Leila. Given that one of Leila's primary motivations to begin measuring carbon was to use the information to inform users, this approach has achieved that aim. It is, however, based on limited available data as it measures in loan length rather than measuring embedded carbon. It also uses a calculator that is not publicly accessible, so therefore this report cannot account for the assumption of 1g of CO^2e assigned as a baseline measure for all items.

This carbon methodology makes great use of the data it has generated, by making it accessible to users at an individual and collective level. However, it is in the early stages of development and the metrics and assumptions it uses to calculate emissions will be further refined.

Edinburgh Tool Library

Context

The Edinburgh Tool Library has been open since 2014 and operates a sharing space dedicated to sharing 'tools, skills and know-how' (Edinburgh Tool Library 2021). It also runs regular workshops, events and classes for users to practice using tools, meet in a social setting and learn new skills from instructors. They have three options for memberships, the standard membership (£30/year), concession membership (£10/year) or the pay-it-forward membership (£40/year), which covers a standard membership and pays forward for another. Once each quarter, the ETL holds a Volunteer Assembly, which is an engagement event held for community groups. After each group has pitched a social improvement idea, the group votes and two most popular ideas will be constructed using volunteer labour and tools from ETL.

Methodology

ETL began to focus on collecting impact data from February 2020, with a specific focus on collecting carbon and financial savings data. They aimed to create a carbon methodology that could not just be applied in Edinburgh, but could be accessed and shared as a resource among other LoTs. The methodology they have developed is based on the principles of avoided emissions, so they calculate the emissions that would have been generated had a tool been purchased new rather than borrowed. Using the software platform MyTurn, they have recorded the weight of each tool, the carbon emission factor and how often it has been borrowed. The carbon emission factor is calculated by determining the embedded/embodied carbon within the parts of each tool. This often requires identifying the embedded carbon of several parts used within one tool. The ETL has created a table of 12 set emissions factors, that represent the most common material compositions of their most common tools, shown in the table below.

Category type	Example	Emissions factor
Solid metal	Crowbar/wrench	3.2485
Solid plastic/rubber	Paint tray	3.218
Mixed plastic/rubber and metal	Paint roller, screwdriver	3.23325

Mixed wood and metal	Chisel, axe	1.87075
Mixed wood and plastic	Garden rake	1.8555
Wood	Mallet	0.493
Aluminium	Spanner, bike tool	7.63
Fabric	Bag	7.96
Cordless power tool	Cordless drill	6.165
Corded power tool (no battery)	Corded angle grinder	3.771
Petrol based (mostly metal)	Lawn mower	4.132
WEE (flashlights, meters)	Sensors	1.760

Figure 4; 12 emission factor categories identified by ETL as the material composition of common tools, sourced https://edinburghtoollibrary.org.uk/carbon-data-for-sharing-libraries/

Each category has been made with assumptions of average weight and percentages of materials used. For example, a solid plastic/rubber tool has an emission factor of 3.218, which assumes an average by weight of 80% and 20% rubber. Each of these emission factors have been calculated using a combination of three carbon emission databases: the ICE database by Circular Ecology and the University of Bath, the Climate Impact Forecast LCA database, and the UK Government GHG Reporting Conversion Factors. Each database has a specific focus on particular materials so using a combination of databases allows the ETL to account for their tool inventory's emissions factors accurately. Using these emissions factors and borrowing data, the ETL uses the following equation to calculate carbon emissions saved per tool.

$$Number\ of\ times\ tool\ was\ borrowed\ instead\ of\ bought\ x\ weight\ of\ tool\ x\ emission\ factor\ =\ carbon\ sav$$

Benefits and Limitations

This is a comprehensive and clear approach to calculating carbon emissions savings. By establishing both the embedded carbon and emissions factor of each item, this approach allows for more consistent measurement of carbon emissions savings. Provided the emissions factors were updated in accordance with updated carbon data released annually, this approach allows libraries to log an emissions factor with each item once and maintain it within the item record. It

This methodology for carbon emissions accounting is broadly applicable, clear and comprehensive for use in LoTs – further categories may have to be added for material compositions not listed above.

also benefits from utilising a range of carbon databases as opposed to relying on just one. The

categories were designed with tools in mind, but the focus on material composition rather than product type means they can be applied to other items, like homeware and kitchen appliances. As a model, it is easy to understand and is clear in outlining the methodological assumptions and logical reasoning used. The library has expressed an interest in coding it's user database so users can see the carbon emissions their loan saves. This approach means the carbon emissions can be calculated for a certain time period, item category or individual member, making this method adaptable for use in numerous applications. It does have its limitations, as it is challenging to accurately measure the embedded carbon in electronic items. There are also limitations to what manufacturing information is available for current models of tools, making it difficult to assign an emissions factor. The first stage of adopting this model is also labour-intensive, as it requires every library item be weighed and categorised, with the corresponding item record updated with the figures for embedded carbon and emissions factor.

North Portland Tool Library

Context

The North Portland Tool Library (NPTL) is a sharing library located in Oregon, USA , founded in October 2004. The majority of those working at NPTL are volunteers and the library is funded using a combination of grant funding and private donations (North Portland Tool Library 2019). Users can borrow from an inventory of over 1,500 tools for free, provided they are over 18 years of age and have proof they are a resident of the North Portland region. Most recent membership figures are from 2015, when the library had just under 5,000 users (USDN 2015). The information for this section was collected from their website and from a case study on the library contained in the USDN report 'Sustainable consumption and Cities' (USDN 2015).

Methodology

The above report calculated the 2013 annual carbon emissions savings linked to NPTL using inputs from two environmental models: the Washington State Department of Ecology's Consumer Environmental Index (CEI) model (Morris and Matthews 2010) and Carnegie Mellon University's Environmental Input-Output Life Cycle Assessment (EIO-LCA) model (Carnegie Mellon University: Green Design Institute 2016).

The CEI model uses a combination of life cycle assessment (LCA) modelling and purchasing information gathered from the Consumer Expenditure Survey administered by the Washington State Bureau of Labour Statistics (Morris and Matthews 2010). The CEI model has generated 700 product categories for common consumer goods and utilises the same 'basket of goods' approach used to calculate the Consumer Price Index (CPI). The CEI model calculates the combined environmental impact of an average basket of consumer goods and services. The CEI figure

decreases if consumers or producers reduce the toxicity, pollution or general waste that arises from the consumption of specific goods and services (Morris and Matthews 2010). The EIO-LCA model is a form of LCA that estimates the materials and energy used, as well as emissions produced, from economic activity in the US (Carnegie Mellon University: Green Design Institute 2016). This model is built using material purchasing information at an industry level, and calculates the industrial environmental emissions at each stage of the supply chain.

Both models are combined to estimate the environmental impact of the avoided emissions (AE) linked to borrowing from NPTL. The model calculates impact at three different stages of the production-consumption process; *upstream*, from resource extraction to retail point, *product use,* when the product is being used by consumers, and *product disposal*, from when it is disposed of (USDN 2015; 55). To determine the saved emissions, each item is assigned a value of kilograms of CO^2e that is calculated using the financial value (in dollars) assigned to that item category. The toxicity measurements used in the CIE model are applied but the majority of tools at NPTL have a negligible toxicity value (USDN 2015).

The models were applied using the assumption that half of the recorded tool loans avoid the purchase of a new item. The model was applied to calculate the impact of the top 20 most frequently borrowed tools. These tools account for 62% of all loans at NPTL, and the findings were used to infer the carbon savings of the remaining 38% of loans (USDN 2015; 56). Below is the table of avoided emissions results, showing how carbon savings were calculated at different stages of the tool's life cycle.

Table 9. Estimated avoided upstream impacts (metric tons CO_2e) of NPTL tool loans in 2013

	Production	Transport	Wholesale	Retail	Total Upstream
Total of Top 20 tool types (62%)	**49**	**0.6**	**5**	**34**	**88**
Top hand tools	10	0.2	0.4	6	**16**
Top power tools	39	0.4	4	28	**72**
Estimate for all tools	**80**	**1**	**8**	**54**	**143**

Notes: Assumes one-half of tool loans avoid the purchase of new items (lowered from NPTL survey results of 66%). Rental data are from North Portland Tool Library for 2013. Tool purchase price estimates are from WorthMonkey.com and HomeDepot.com.

Benefits and Limitations

The benefits of this model is that by applying an LCA model framework, it is designed for a complete analysis of carbon emissions saved at all stages of production and consumption. It also allows for specific product comparisons and with the right data, can be used on most commodities.

Despite it's impressive range in applying an LCA across the production-consumption process, this model relies on economic indicators to assume carbon emissions and is not easily adaptable from it's exclusive use on tools.

However, the method used here uses economic data to measure and make assumptions of value from. As a result, the environmental impact of each stage is inferred rather that directly accounted for, a limitation which has been acknowledged (USDN 2015; 32). Additionally, the CEI model that includes environmental metrics has a limited scope by measuring only certain indicators, like ecosystem toxicity, air pollutants etc. Logistically, this would be a challenging model to implement at Benthyg, as it would require an creating new categories for items, based on a different consumer information and the new valuation of all items inventoried.

Recommended methodology for Benthyg Cymru

When engaging with any carbon accounting exercise, there are numerous approaches an organisation can take. As is seen in the above case studies, the information, resources, inventory and basic assumptions that each organisation has shape the methodologies they are able to use. When selecting a methodology to use for a library, it is important to consider a number of factors, outlined below. Essentially, organisations must consider how much information they have access to, how expansive the carbon accounting will be, and what assumptions they are willing to make in the process.

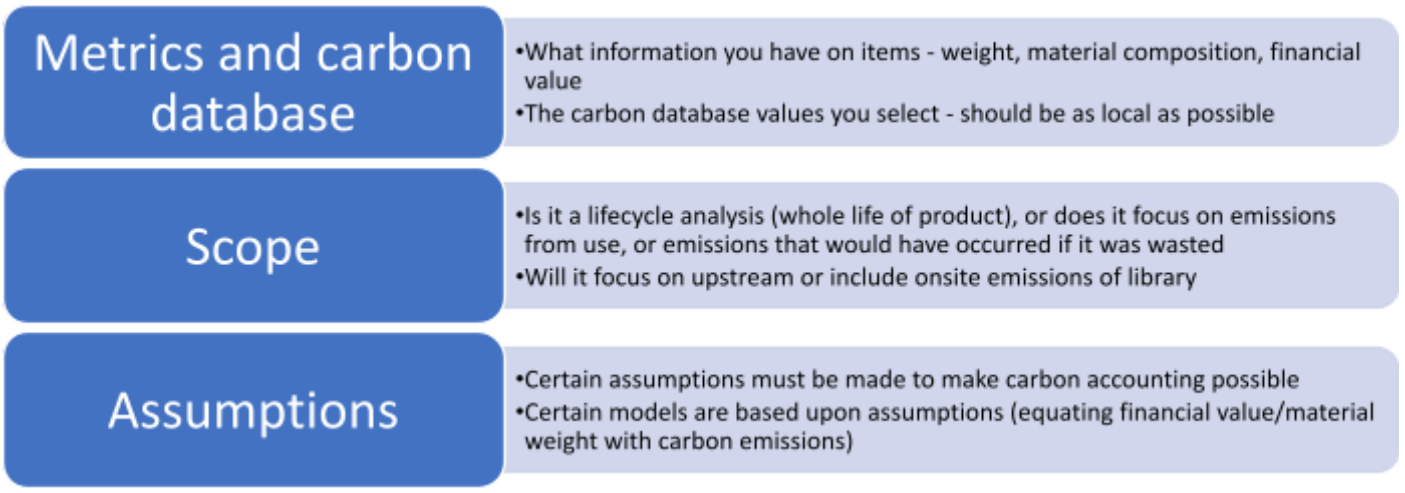

Figure 6; Diagram showing three key components LoTs should consider when choosing a carbon methodology, created for this report.

Based on the information gathered from the above case studies, the methodology applied by the Edinburgh Tool Library would be the most suitable option for Benthyg Cymru in implementing carbon emissions accounting. By developing generic material composition categories, it can be applied beyond tools to other library items. It is based on three extensive and regularly updated carbon databases that are UK specific, so the carbon emissions data is geographically accurate. It uses embedded carbon of new tools as a metric for calculating emissions, which is less variable than financial value and more accurate than using weight/loan duration as a proxy. Depending on the inventory at the Benthyg locations, more categories may be needed but this can be achieved with the available carbon data. Furthermore, the equation used to calculate emissions is adaptable and can produce results at different levels, customising them per user, product type or time period, which makes the results usable across multiple contexts. Finally, it has been designed as a methodology to be shared – its reasoning and data are publicly available and the ETL have created resources for other libraries to learn from and adapt to work in their contexts. This methodology appears to be the best option for Benthyg Cymru to apply across their member network.

Recommended next steps:

1. Categorising each item in Benthyg's inventory using the ETL 12 categories
    a. Creating new categories for fabric/textile goods, if necessary
2. Recording the weight of each object in Benthyg inventory
3. Logging both the weight and the emissions factor (found in Figure 4) on the LendEngine database
4. Enter figures into ETL equation to produce the emissions saved per loan per item, a figure that can be displayed on the LendEngine platform or in publicity
5. Using the LendEngine data visualisation features to track and compare carbon emissions, and code so user's carbon savings are made available to them on the dashboard
6. Resulting data can be used to create a 'data story' that can be featured on Benthyg Cymru's website – example can be seen on ETL website (https://edinburghtoollibrary.org.uk/why-you-should-join-your-tool-library-a-data-story/)

Future opportunities

General observations and recommendations

- The wider network of LoTs in the UK and globally would benefit from a greater focus on impact metrics, either carbon, social or financial, to quantify the significant impact that lending has on people, the planet and profits.
- Current carbon accounting efforts in LoTs tend not to be standardised and as a result, there is a notable variation between carbon accounting methods used, which makes them hard to compare. Further efforts towards standardisation would allow libraries to learn from one another and share information
- Aside from one Google group in the US, there do not appear to be any networks of LoT organisers and members online. Introducing a LoT organiser network in the UK could be beneficial for organisers to share carbon methodologies and data collection practices with one another – many participants contacted during this research wanted to calculate carbon but did not know how to start.
- A significant proportion of libraries contacted expressed interest in the concept of using carbon emissions as an impact metric, but were not sure how to begin the process or only focused on operational processes.

Future research

Social value

Below are some of the practices that LoTs use to measure impact other than carbon, sourced from LoT impact reports that were either provided by the organisation or available online (Inner West Tool Library 2019; Team Ontario - Social Innovation Academy 2019; SHARE Oxford 2021). These could be applied practically to LoT operations or studied in future research.

- **Photos** - that users take of the projects they have completed and send them in
- **Testimonials** – specifically those that ask what the user would have done without the LoT
- **Mapping** – by collecting data on where users lived, how far they commuted to the LoT and by what means, the LoT can highlight the role they have in community engagement and reducing transport-based emissions
- **Community items** – having items available that are commonly used in community gatherings or activities – projectors, barbeques, disco balls, gazebos
- **Workshops** – hosting events to teach people how to use tools or complete tasks, with a social element
- **Community outreach projects** – collaborating with community groups to run a joint event that showcases Benthyg's work while contributing to a social cause.
- **Social media engagement** – many LoTs are investing in developing a strong online presence across multiple platforms, using this to showcase events or available items.

Financial value

Financial value was often measured in impact reports and on the websites of LoTs. Here are some of the metrics used:

- Total financial value of item inventory
- Total savings made by collective LoT users
- Savings made annually per member (total savings/active memberships)
- Value of volunteer hours (based on minimum wage statistics of country)
- Total financial value of item inventory
- Comparisons of cost to borrow item and notional cost of items not purchased

Appendix

Appendix A
Glossary of terms [1]

CO^2 – Carbon Dioxide

A greenhouse gas with significant radiative forcing capacity and the metric used in carbon accounting

CO^2e – Carbon Dioxide equivalent

A metric used to compare the emissions from greenhouse gases, based on their Global Warming Potential, compared to the emissions of the equivalent amount of carbon dioxide with the same Global Warming Potential

CEF – Carbon Emission Factor

A factor that links specific activities or materials to greenhouse gases produced.

DEFRA – Department for Environment, Food and Rural Affairs

UK government department responsible for environmental protection, and the source of a primary UK carbon database used in carbon emissions calculations

GHG – Greenhouse Gases

The seven direct gases established in the Kyoto Protocol as having a positive radiative forcing effect, and their presence in the atmosphere contributes to global warming

IPCC – Intergovernmental Panel for Climate Change

An international scientific body that produces research relating to climate change. The IPCC produces collaborative reports every few years, that assesses information in order to understand how human activity relates to the processes of climate change.

LoT – Library of Things

In this report, refers to the range of sharing initiatives or organisations that function to allow users lend or borrow common household items for a predetermined length of time.

LCA – Life Cycle Assessment

A methodological approach that calculates the environmental impact of a product, material, process of activity has during it's defined lifespan

[1] Definitions for these terms were used from the following sources: Clim Foot. 2020. *Glossary of Terms*. Angers, France: Agence de l'Environnement et de la Maîtrise de l'Energie. Available at: https://www.climfoot-project.eu/en/glossary [Accessed: 01 Mar]. , https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs, https://naei.beis.gov.uk/overview/ghg-overview, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Carbon_dioxide_equivalent

Appendix B

Outline of research questions asked in interview with participants

	Interview questions
1	Could you briefly describe your work experience at this organisation – how long have you worked here and in what role(s)?
2	What methodology does your organisation use to calculate the carbon emission savings of lending items?
3	What made you choose that method/approach to measure carbon emission savings?
4	What do you think the benefits of using that method/approach are?
5	What do you think the limitations of using that method/approach are?

Appendix C
Information on libraries contacted during research

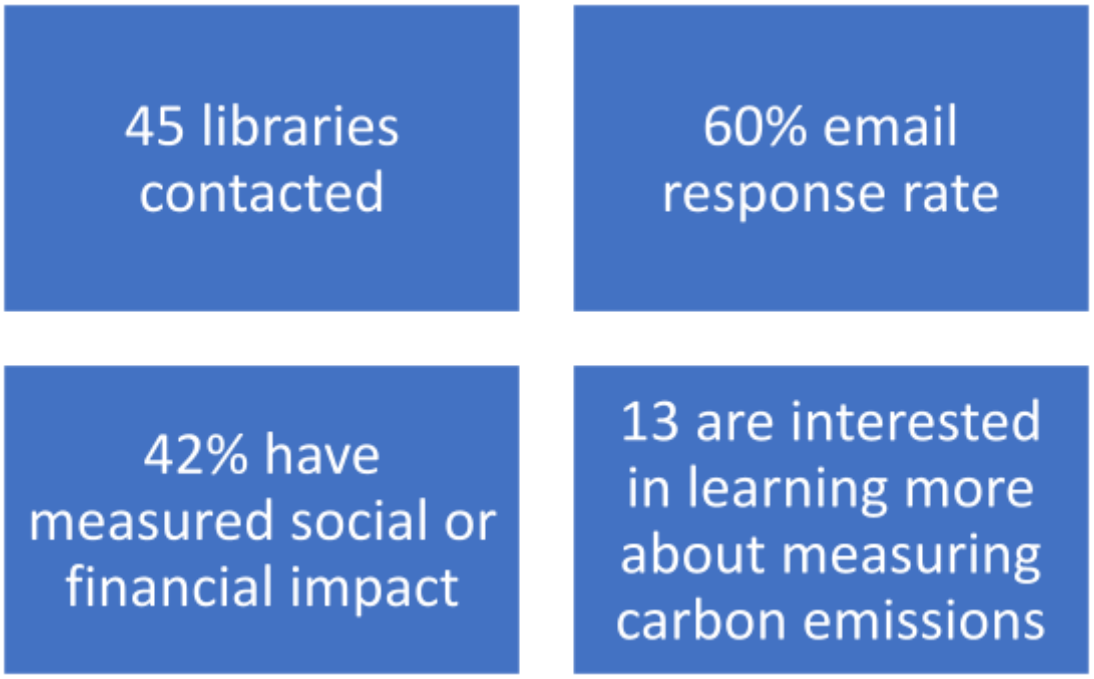

Figure : Note - the measurement of social or financial impact was based upon whether the library has published any financial or social impact metrics online or in impact reports.

Appendix D

Databases used in case study methodologies

Databases	Links
ICE (Inventory for Carbon and Energy)	https://circularecology.com/embodied-carbon-footprint-database.html
Climate Forecast	https://climate.impactforecast.org/about/
Greenhouse Gas Reporting: Conversion Factors 2020, UK Government	https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2020
IPCC 2013 conversion figures	https://www.ipcc.ch/site/assets/uploads/2018/02/ipccwg3ar5annex-ii.pdf

Methodologies	Links
Edinburgh Tool Library	https://edinburghtoollibrary.org.uk/carbon-data-for-sharing-libraries/
CEI	https://doi.org/10.1111/j.1530-9290.2010.00246.x
EIO- LCA	http://www.eiolca.net/Method/eio-lca-method.html
Carbon Footprint	https://www.carbonfootprint.com/calculator.aspx

Appendix E
Relevant section of research brief relating to this report

• Review existing methodologies used by other UK Libraries of Things and similar repair/reuse initiatives

a. Make recommendations on both how the Benthyg Cymru network members can individually measure and monitor key metrics,

b. And how Benthyg Cymru central office can regularly and meaningfully collate this data.

The priority is to focus on carbon savings but the review may identify opportunities to include additional outcomes.

- **Primary measurable:**

Carbon and Environmental Impact savings

- reduction of items sent to landfill
- reduced consumption
- carbon saved.

Potentially to include in addition:

Social Value

- Individual and community wellbeing, community cohesion. High street regeneration.

Economic Value

- Reducing living costs by borrowing, sharing and maximising resources which already exist in our communities.

~

• This research will need to include a topline review of the reporting and measurement functionality provided by Lend Engine, the existing online borrowing platform used by most Benthyg Cymru network members, to assess what metrics are currently available via this platform.

• The exercise should deliver clear and practicable recommendations for Benthyg Cymru network members and central office to measure their individual and collective impact using a robust and clear methodology.

• This may include achievable short-term goals using available resources (e.g. Lend Engine) as well as long-term targets to embed a gold-standard approach (e.g. that could form part of the spec for a bespoke borrowing platform).

• The short-term goals must include a degree of flexibility depending on the resource afforded to each project, with a consistent baseline measurement that is achievable by all current network members.

Appendix F
Snapshot from the ETL shareable carbon data emissions calculation guide

Getting Started

This is a shared resource for sharing libraries and other organisations. We believe strongly that reuse is one of the best ways to make an environmental impact, and we hope that these resources help us all to show that impact.

Please use and share these resources, and come back to contribute your own.

Each resource should help anyone to create value from their data.

- For sharing libraries using myturn.com
  - How to use your myturn data about members
  - How to use your myturn data to show money saved
  - How to use your myturn data to show carbon saved
- For orgs using their own systems
  - How to collect data
  - How to use your data to show money saved
  - How to use your data to show carbon saved

Visualisation tools for your data

Here is a data story we have created with some of the resources on these pages

Questions

Tracking all data recipes

Bibliography

Carbon Footprint. 2020. *FREE CARBON CALCULATORS: For Individuals And Small Businesses*. Basingstoke, Hampshire: Carbon Footprint Available at: https://www.carbonfootprint.com/calculator1.html [Accessed: 1 Mar].

Carnegie Mellon University: Green Design Institute. 2016. Economic Input-Output Life Cycle Assessment. Pittsburgh, Pennsylvania Carnegie Mellon University.

Clim Foot. 2020. *Glossary of Terms*. Angers, France: Agence de l'Environnement et de la Maîtrise de l'Energie. Available at: https://www.climfoot-project.eu/en/glossary [Accessed: 01 Mar].

DEFRA. 2021. *UK's carbon footprint 1997-2018*. London, England Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/979588/Defra_UK_carbon_footprint_accessible_rev2_final.pdf

Edinburgh Tool Library. 2021. *Our Manifesto*. Edinburgh, Scotland Available at: https://edinburghtoollibrary.org.uk/about/ [Accessed: 01 Mar].

Inner West Tool Library. 2019. *Inner West Tool Library Impact Report*. Inner West, New South Wales, Australia: [Accessed: 12 Feb 2022].

IPCC. 2013. *Annex II: Metrics & Methodology*. Available at: https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_annex-ii.pdf [Accessed: 01 Mar 2022].

IVL: Swedish Environmental Science Institute. 2019. *Klimatpåverkan från olika avfallsfraktioner*. Stockholm, Sweden: Available at: https://www.ivl.se/download/18.34244ba71728fcb3f3f925/1591705294206/B2356.pdf

La Manivelle. 2021. *Join the Adventure*. Geneva, Switzerland: Available at: https://manivelle.ch/en/nouveaux-coops [Accessed: 27 Feb].

Morris, J. and Matthews, H. S. 2010. Development of a consumer environmental index and results for Washington state consumers. *Journal of Industrial Ecology* 14(3), pp. 399-421.

North Portland Tool Library. 2019. *North Portland Tool Library - About Us*. Portland, Oregon Available at: http://northportlandtoollibrary.org/ [Accessed: 01 Mar].

SHARE Oxford. 2021. *SHARE Oxford Impact Report 2021,*. Oxford, England Available at: https://shareoxford.files.wordpress.com/2021/05/share-oxford-impact-report-2021.pdf [Accessed: 16 Feb 2022].

Team Ontario - Social Innovation Academy. 2019. *Environmental and Social Impacts of Tool Libraries Within Communities*. St John's, Newfoundland and Labrador, Canada: [Accessed: 28 Feb 2022].

UK Government. 2021. https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2021. In: DEFRA ed.

USDN. 2015. *Sustainable Consumption and Cities: Approaches to measuring social, economic, and environmental impacts in cities* Port Washington, Wisconsin: Available at: https://www.usdn.org/products-sustainable-consumption.html [Accessed: 13 Feb 2022].

Ville de Geneve. 2021. Climate emergency: the City takes measures to reduce CO2 emissions. *Ville de Geneve News*. Available at: https://www.geneve.ch/en/actualites/climate-emergency-city-takes-measures-reduce-emissions#:~:text=In%20February%202020%2C%20the%20City,becoming%20carbon%20neutral%20by%202050. [Accessed: 28 Feb 2022].

Zero Waste Berlin. 2022. *Zero Waste Berlin: Berlin Ohne Abfall*. Available at: https://zero-waste-berlin.de/ [Accessed: 03 Mar].