D3.1 State of the art on material flow data in the built environment

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Abstract	This report summarises the key findings and conclusions from Work package 3 – Map flows of built environment materials, Task 3.1 Current data on existing built environment and/or material flows in cities. Each city completed a template to record data across various aspects of building data; material and product data; reuse, recycling and other waste management data; processes and standards data, amongst others. From this exercise, it was possible to understand what datasets existed and how relevant and accessible they might be in each city. This information was collected to understand what data might be currently available for the work being undertaken in other work packages, notably WPs 4, 5, 6 and 8. Therefore, some exploration of the ‘use cases’ for data in each of these WPs, alongside other general use cases for data have been evaluated. This evaluation extends beyond the city scale analysis to include international research and best practices, to better understand the range of methodologies and the data that might be required to apply them. This report will be adapted for open publication, alongside the 4 detailed city data capture spreadsheets that were completed to January 2020. The next stage of this task (3.1) will expand upon the requirements for data, gaps in data provision (based upon the city data currently available), and recommendations for filling these data gaps, based upon discussions with local stakeholders.

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i. Executive Summary

This report summarises the key findings and conclusions from Work package 3 – Map flows of built environment materials, Task 3.1 Current data on existing built environment and/or material flows in cities. It summarises the findings from an initial data mapping exercise conducted in each of the CIRCuIT cities and Helsinki/Vantaa region, supplemented by reviews of innovations and practices that could support material based mass scanning of existing building stock. Additionally, the reasons for having such data were also explored, focussed principally upon the other work packages within the CIRCuIT project and their identified need for data, referred to as 'use case scenarios' in this report.

Each city completed a template to record data across various aspects of building data; material and product data; reuse, recycling and other waste management data; processes and standards data, amongst others. From this exercise, it was possible to understand what datasets existed and how relevant and accessible they might be in each city. This information was collected to understand what data might be currently available for the work being undertaken in other work packages, notably WPs 4,5,6 and 8. Therefore, some exploration of the 'use cases' for data in each of these WPs, alongside other general use cases for data have been evaluated. This evaluation extends beyond the city scale analysis to include international research and best practices, to better understand the range of methodologies and the data that might be required to apply them.

This report relates to the findings to date in Work package 3, Task 3.1, and provides an initial set of findings upon which to complete this task and feed into multiple other workstreams. In particular, the review of each city data map reveals variation in terms of data is available, accessible and up to date, as summarised in this report. This baseline information allows identification of best practices in each city that could be transferable to others, subject to greater evaluation and stakeholder engagement activities (as planned for Autumn 2020). Each of the city data spreadsheets are included in the Appendices and form a snapshot in time. The intention is to continue to update these datasheets throughout the lifetime of the CIRCuIT project and have this information openly accessible from the website for others to use and provide feedback on other data that might not have been captured. To facilitate this ongoing feedback from stakeholder, this technical report will be adapted for open publication, alongside the 4 detailed city data capture spreadsheets that were completed to January 2020.

The next stage of task 3.1 will expand upon the requirements for data, based upon use case scenarios, i.e. do we have enough of the right data in the correct format to adequately fulfil the multifaceted approaches to delivering circular and regenerative cities. The answer is a resounding 'no' which is where the focus of WP3, working alongside other workstreams will now move to. This includes developing comprehensive recommendations in each city for filling data gaps, based upon discussions with local stakeholders; closer examination of the use case scenario requirements; and deeper evaluation of the innovations and practices that could support material based mass scanning of the existing built environment.

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1. Introduction

1.1. General introduction

The circular economy is increasingly accepted as a long-term solution to the issue of maintaining and, where necessary, increasing the provision of resources to society in a manner that maximises efficiency and minimises the negative environmental, economic and social externalities that result from a linear economy. To achieve this requires decoupling resource consumption from externalities by way of closed loops and system efficiency.

CIRCuIT is a Horizon 2020-funded project aiming to support the creation of regenerative cities by promoting and implementing circular construction approaches. Running from 2019-2023, it brings together 29 ambitious partners from Copenhagen, London, Hamburg, and the Helsinki region working across the entire built environment value chain who will work collaboratively to enhance knowledge- and resource- sharing and uptake of the results. To bridge the gap between theory, practice, and policy, the consortium will deliver a series of demonstrations, case studies, events, training sessions, and other dissemination activities that showcase the possibilities of circular, regenerative built environments. We want to increase the regenerative capacity in the four cities; to reduce the yearly consumption of virgin raw materials by 20% in new built environments; and to show cost savings of 15%. The project will implement innovative solutions focussed on the following areas:

• Urban mining and reverse cycles (dismantling buildings to re-use and recycling of materials);

• Extending building life through transformation and refurbishment;

• Designing for disassembly and flexible construction

Each city cluster will support the delivery of nine demonstrations (three per area) that make a case for how circular strategies and principles can be implemented, replicated, and scaled.

Supporting these core areas are several cross-cutting work packages, including development of:

- Consistent and comprehensive approaches to data collection, analysis and management to support the demonstrators and to enable the aim for moving the concept of buildings as material banks into city scale understanding and implementation (WP3 Map flows of built environment materials - focus of this report).

- Replicable recommendations that can support cities in overcoming barriers and implementing circular construction solutions and initiate changes at system level (WP7 Governance, instruments and urban planning approaches).

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- A “Circularity Hub” - an open, accessible data and information platform to support acceptance and implementation of circular construction projects (WP8 Circularity Hub)

- The CIRCuIT Academy to disseminate project experience, knowledge and deployment practices to cities and the construction industry (WP9 the CIRCuIT Academy).

1.2. Why measure material stocks and flows of systems?

Material resources are the fundamental units of built environments, and achieving their circularity requires applying the principles of the ReSOLVE framework. This framework, devised by the Ellen MacArthur Foundation, promotes:

- **Re**generation of natural resources and the environments impacted by their extraction
- **S**haring of available resources to minimise unnecessary duplication of resource provision for the same utility
- **O**ptimisation of existing resource use patterns to maximise utility and value per unit of resource
- **L**ooping of resource flows by redirecting waste flows for use as inputs for other activities
- **V**irtualise activities that are currently carried out using physical material resources
- **E**xchange resources with high environmental impact for those with low impacts.

Design innovations and business models for achieving these interventions at the building level continue to be demonstrated. However, for a true circular *economy* to emerge, these principles must also become features of entire economies. To realise the necessary large-scale transition requires changes to policy and public services, the identification and exploitation of commercial niches and circular business models, technological advancement, and consumer behaviour change, such that entire lifecycles of built environment materials are designed for circularity. The overarching aim of the CIRCuIT project is to develop tools, methods and recommendations to enable and enact the changes necessary to achieve economy-wide circularity.

However, in order to identify suitable obstacles, bottlenecks and opportunities for new tools and approaches, a thorough understanding is needed of the existing landscape of material stocks[1] and flows[2] within the systems under study (in this case the partner city regions of Copenhagen, Hamburg, Helsinki Region/City of Vantaa and London). For example, useful information might include:

[1] Defined here as materials that are currently embodied within existing built structures

[2] Defined here as the routes materials take before being built into a structure or when they are released from the structure, through the supply chain or after being released during the refurbishment, retrofit or demolition of a built structure.

- What materials are currently embodied within the system as a whole, and in what quantities?
- The locations of material stocks at the sub-city/sub-regional level (e.g. district-level, building-level)
- The overall volume of materials entering or exiting the system
- The origin of materials entering the system
- The rate at which materials are, or will be, consumed under current or future rates of works (i.e. rates of construction, refurbishment, retrofit)
- The rate at which materials are, or will be, released from works (i.e. construction, refurbishment, retrofit, demolition)
- The proportions of materials which go to various routes or destinations (i.e. reuse, recycle, energy recovery, landfill/incineration) at the end of their use cycle
- The potential to optimise their value and utility within their current use cycles, and thus reduce demand
- The potential to divert existing waste streams towards circular routes at the end of their current use cycle
- The likely impacts of relevant policies and trends

While assumptions and estimates can be made about these stocks and flows, a true representation cannot be assembled – and hence interventions cannot be optimally designed – without a solid evidence base comprising accurate, reliable and complete data. In a more direct sense, data is fundamental to many of the tools and approaches that are to be developed within other CIRCuIT workstreams, such as the analysis of potential for urban mining (WP4) and building stock transformation (WP5) at area-wide scales, the development of policies and planning approaches to encourage the circular economy (WP7), the sourcing of materials to be posted to the Material Exchange Portal (WP8), the visualisation of stocks and flows via the Circularity Atlas (WP8) to enable decision-making regarding policies, behaviours and commercial ventures. As such, a thorough mapping and assessment of the available data on material stocks and flows within each 'city data ecosystem'[3] was required – this was the focus of WP3 Task 3.1.

1.3. The purpose and structure of this report

This report briefly summarises the results and insights obtained from the data ecosystem mapping undertaken for WP3 task 3.1. It then proceeds to describe the state of the art on data availability and utilisation through best-practice use cases. These comprise methodologies that can be employed to achieve or support the objectives of other CIRCuIT work packages, and which make use of the types of data identified in the mapping exercise. The existence and availability of relevant data is highlighted throughout. For each use case an overview of data availability is described in brief and highlighted using selected examples. For brevity, the intention is not to list all data found

[3] The 'City Data Ecosystem' is defined for the purposes of this project as all of the data that represents or relates to the physical system of interest (in this case material stocks and flows), as well as any relevant interlinked processes (such as economic factors that influence material stocks and flows).

as part of the ecosystem mapping; rather, it is to demonstrate its potential uses and to help define data gaps.

Use cases related to the following circularity-related topics (which correspond to other CIRCuIT work packages) may be found in the sections indicated:

- **Urban mining and reverse cycles (section 4.1)**
- **Extending lifecycles through transformation and refurbishment (section 4.2)**
- **Design for disassembly and flexible construction (section 4.3)**
- **Governance, instruments and urban planning (section 4.4)**
- **The Circularity Hub (section 4.5)**
- **General use cases (section 4.6)**

2. Approach to city data ecosystem mapping

The mapping exercise of the city data ecosystem sought to identify and gather information on all of the relevant data indicating historical, current, or future material stocks and flows within the CIRCuIT city regions.

The approach consisted of firstly considering the potential routes taken by a material (whether in its raw form or as a constituent of a building component or product) as it flows and is contained within stocks throughout the city/region system, from resource extraction to end-of-life waste treatment. Additionally, data on contextual processes that may influence material stocks and flows through time (such as projections of housing need or forecasted construction sector economic performance) were included. This conceptual model allowed a mapping of the potential points and processes of data collection throughout the city system, which could be used to identify relevant stakeholders and data subjects to look to when searching for data and information[4]. Thus, the approach included identifying data collected not only at the point of construction works, but also throughout the upstream (i.e. supply) chains and downstream chains (i.e. waste, circular routes) – these were considered to represent material flows, as well as building and infrastructure standing stock data from which quantities embodied within material stocks may be estimated. The aim was to find data and information on as many material flows as possible, as well as on the long-term material stocks (i.e. within building and infrastructure stock). Figure 1, overleaf, displays a hypothetical representation of the flows of materials, the points where data is captured on those material flows, and the flows of data and information.

To map the entire material stock and flow data ecosystems in the holistic sense described, a wide range of datasets from many sources were explored (see City data sheet Appendices), covering as many points along material resource and waste cycles as possible. The potential requirements for other work packages, as described in the project grant agreement, were also factored into the search. Broadly, data was sought that could indicate:

- *Inflows* of materials or products to the building and infrastructure stock, as indicated by data such as data on installations, or (indirectly) material sales data;
- *Building and infrastructure stock figures*, such as numbers of buildings, total floorspace, kilometres of track, split of building and infrastructure types;
- *Current material stocks* embodied within building and infrastructure stock;
- *Circular flows* of materials or products at end of service life to a new use cycle within the economy – i.e. reuse, remanufacture and recycling of building components, products and materials;
- *Outflows / waste flows* of materials or products at end of service life in buildings and infrastructure stock to landfill, incineration, energy recovery or fly-tipping;

[4] This model was also informed by the work of Alistair Wilson (personal communication, January 2020), who created a similar model displaying material flows and information on those material flows as part of his research

- *Past, current and future demand* for buildings and infrastructure, and for the materials and products they consist of;
- *Future arisings* of materials or products at end-of-use within the city;
- *Externalities* – the environmental, social and economic impacts arising from the extraction, operation, transport and disposal of relevant products and materials;
- *Contextual data,* i.e. data on factors that influence or are related to material stocks and flows, such as demand for new housing;
- *Geographical and land-use data* that could provide a basis for any mapping and visualisation of any relevant geolocated data identified

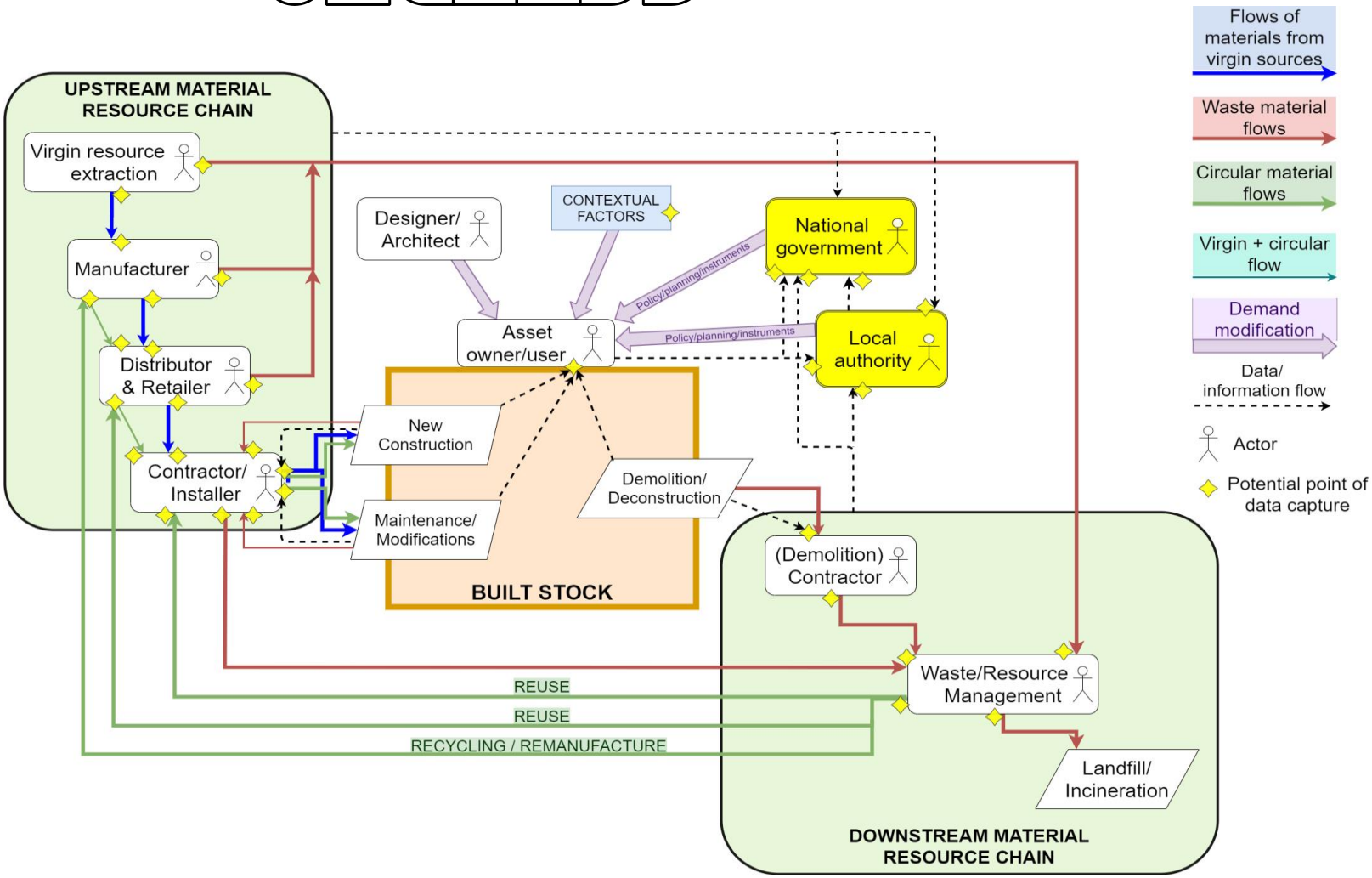

Figure 1: Schematic of actors, material flows and potential points of data capture in cities and regions.

Note that not all flows of information and data are represented here. Within (and, where appropriate, between) upstream and downstream material chains there is also likely to be data and information sharing that may indicate material flows, such as orders from distributors/retailers to manufacturers for restocking.

This schematic was influenced by communications with and unpublished materials of Alistair Wilson, PhD candidate at Loughborough University, whose research deals with the incentivisation for data capture and sharing in the construction industry, with an emphasis on the potential uses for blockchain technology.

A basic template of the main data types to be identified and potential sources[5] was assembled and shared with the partner city clusters to serve as a guide for the City Data Ecosystem Assessment (see Appendix 1 – city data mapping template). Partner institutions from each city – led by Building Research Establishment (BRE; London), Technical University of Denmark (DTU; Copenhagen), Helsinki Region Environmental Services Association (HSY; Helsinki), Freie und Hansestadt Hamburg (FHH; Hamburg), along with assistance from other partners – took responsibility for completing the template with the data sources available to them. In London, the search was conducted first based on data sources already known through BRE's experience working in the materials and waste management sector, followed by a review of data sources cited in academic publications and grey literature, followed by a wide-ranging internet search of reliable sources. BRE then engaged with over thirty experts and stakeholders (including academics, local authorities, industry associations and membership bodies, supply chain organisations, government data curators, and others) on any relevant data they collect themselves or are aware of others collecting, with further stakeholder engagement planned. Other city cluster representatives reported undertaking similar approaches to identifying data.

A spreadsheet (see Appendices) was populated with the name, description and source of potentially useful data and information sources. Additionally, and where available, useful metadata was gathered, such as:

- The accessibility of the data (i.e. open, public, private; see section 2.1 for definitions)
- The granularity of the data (spatial and temporal)
- The quantity of data (number of data points)
- The time range covered by the data
- Whether or not the dataset is actively updated

Note that the data itself was not collated; also that in many cases the metadata was incomplete.

2.1. Note on types of data accessibility

An important consideration for the utility of identified data in other CIRCuIT workstreams is whether it is licensed for open use, or whether special permissions or licenses must be obtained.

Open data is that which can be freely used, modified, and shared by any potential user for any purpose[6]. Open data therefore represents the most straightforward and short-term opportunities for use in CIRCuIT workstreams.

[5] Note that it was expected that some of the desired information (see list above paragraph), such as future demand for materials, would rely on proxies and inferences rather than actual measurements, and consequently categories such as 'Rate of demolitions' was included, from which inferences about material outflows from the building stock could be made.
[6] http://opendefinition.org/od/2.1/en/

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Public non-open data is defined, for the purposes of this project, as data which is viewable by all but cannot be freely utilised for the viewer's own purposes. This may include, for example:

- Spreadsheets available for download but which may not be used as a component of published studies and analyses without special permissions or license agreements;
- Data tables and statistics presented in reports and news stories for which the underlying data is not made available;
- Datasets which are only made available upon payment
- Datasets which are only available to users with a special license (such as a Public Sector Mapping Agreement license, which grants UK public bodies access to Ordnance Survey data not freely available to the public)

While public non-open data may still be obtained and used eventually, this is not guaranteed, and will often require additional effort and costs to obtain. However, it is the most common type of data identified.

Private data is defined, at least for the purposes of this project, as data which is collected by a private entity for their own purposes and is not viewable by the public. Often, the existence of private data is not made known to the public, generally because it only serves to fulfil a narrow aspect of an organisation's operations (e.g. a builders' merchant keeping a record of sales volumes for different materials and products in order to ensure optimal ordering). While private data is unlikely to be widely obtainable within the time frames of CIRCuIT, in aggregate it can provide a degree of granularity and completeness that is not covered by open and public data at this time. Where not constrained by data protection concerns and legislation, collating private data and providing it in a standard format under an open license could allow a substantially more accurate picture of material stocks and flows. Compliance with data privacy regulations would typically preclude any personal data on individuals as being accessible in any event.

3. Overview of current material stock and flow data in cities

This section will provide an overview of trends in the identified data across all four city regions. Ascertaining patterns within the city data ecosystems was difficult because of the very large number of datasets identified, and because of the large variability in subjects and attributes of those datasets. This variability was often higher within cities than between cities, and higher within data subject (as detailed in the data collection template, see Appendix 1) than between data subjects. As such, making comparisons between cities and between data subjects is redundant in many cases. However, some broad trends, listed in the following sections, were observed. Where noticeable differences were observed between cities and/or between data categories, these are highlighted.

3.1.1. Completeness of city data ecosystems

The 'completeness' of a city data ecosystem is defined here as the extent to which data is available for all of the actual material stocks and flows taking place (as depicted in Figure 1). Additionally, it refers to the extent to which the data covers all relevant aspects of each actor, stock and flow. For instance, if residential building stock data is well covered, while non-residential building stock and infrastructure stock are not, then the data ecosystem in incomplete because it does not accurately represent the actual physical system.

Overall, the data mapping identified a large volume of data across multiple different points of construction material resource cycles within cities. There were some points of these cycles upon which noticeably higher volumes of data are produced, such as current housing stock, as well as some prominent gaps where data is either not gathered or not made public, as described in the sections below.

Overall, there is a lack of completeness in terms of capturing a full picture of existing material stocks and flows within the city clusters. Data from which predictions can be made for future material stocks and flows – an important category of data for the CIRCuIT project – is also limited. In some cases, specific data required for some of the suggested use cases is not available in all city clusters. For example, data on measured material quantities within building stocks is absent in all cities, and supply chain material flow data is also mostly lacking. Though data-dependent use cases and CIRCuIT objectives can be supported to an extent using the identified data (assuming adequate data accessibility), significant benefits may be obtained via improved completeness of data across the data subjects specified. Recommendations of areas for improving data capture will be elaborated in forthcoming WP3 deliverables.

Supply chain

There was little data identified on the supply chains of construction materials in terms of data volume for any of the four city clusters. Compared with the potential points of data capture in the upstream material flow data ecosystem

(see Figure 1), very little actual data capture was identified. In some cases, government bodies collect data from supply chain organisations, such as mineral extraction volumes and sales data from distributors and retailers, however there is very little data from which a granular and accurate representation of material flows may be gleaned. However, there is likely to be substantial data collected privately by supply chain organisations on the volumes of materials being handled and exchanged with up- or downstream actors in the supply chain; if this data was centralised, aggregated, made openly accessible and, where necessary, anonymised, it could help to plug major gaps in understandings of material flows.

Residential building stock

Data was identified on residential building stock for all four city clusters. At minimum, this included aggregated area-level numbers of residential buildings, with breakdowns of numbers according to characteristics of the buildings such as age, number of bedrooms, built form and so on. Building-level datasets also exist in all four city clusters, providing a good degree of granularity and a more precise indication of building stock characteristics, and which may be aggregated.

Non-residential building stock

Generally there was less systematic data collection on non-residential building stock, such as commercial buildings, industrial buildings, and retail, despite these being estimated to represent large proportions of stock, though such data does exist to a certain extent in Hamburg, Helsinki/Vantaa, and Copenhagen. This is fairly extensive in the latter two city clusters due to legislation requiring the provision of building-level data for national building registers. In London, there is very little useful data on non-residential building stock.

Infrastructure stock

‘Infrastructure’ is taken here to refer to the physical infrastructure underlying transportation (e.g. roads, rail, bridges, tunnels, cycleways, car parks), utilities (e.g. electricity grids, water pipe networks, sewers, waste facilities), telecommunications, and public space.

The extent and usefulness of infrastructure stock data varies by city. Some infrastructure data was identified for all city clusters. For Helsinki, a high volume of physical infrastructure stock data is available, is regularly updated and apparently covers the majority of physical infrastructure. A smaller volume and precision of data was identified for infrastructure in London, Copenhagen and Hamburg, and often certain types of infrastructure were not represented in the data. However, it is known that, at least in the case of London, a large volume of data is collected and held privately by organisations and contractors responsible for installing and maintaining infrastructure.

Material stock data

‘Material stock’ here refers to that embodied within building and infrastructure. In none of the city clusters were per-building or per-infrastructure asset material quantities data identified. However, in all cities

there is data from which building stocks may be calculated using techniques developed within the field of Material Flow Analysis, such as Denmark's BBR system and Finland's Regional Base Register (which contain material contents and dimensions data), and building typology information for Hamburg and London (see section 4.1.1.3).

Upstream and downstream material flow data

This refers to data on material flows before they enter the built stock and after they leave the built stock; namely, extraction, manufacturing and supply chain (upstream), and, waste flows and resource management (downstream). Identifying the points and processes in resource chains at which targeted interventions for circularity will be most effective requires a detailed understanding of material flows both up- and down-stream from built stock. However, in all cities, relatively little data was identified at these parts. The disparate data that do exist do not cover the scope of possible inflows, crossflows and outflows, and do not always adhere to standardised units and formats. Data from multiple points throughout the supply and waste chains are necessary to build a truly accurate picture of flows and would likely present more granular data than the top-down data offered by public bodies. It appears that there are a number of points along resource chains where data capture indicating resource flows may be occurring but has not yet been identified, such as through supply chain transactions and data from contractors or installers.

Waste management and circular material flow data

Data on waste management is more complete and extensive than other segments of material flow chains. In all city clusters, data is readily available for tonnage/volume, and origin of construction and demolition waste (CDW), generally split by material/waste class, in part owing to reporting requirements under the European Commission's Waste Framework Directive (Directive 2006/12/EC). In some cases, data on the destination of waste is also captured. A large quantity of this waste data is generated from waste treatment facilities, with additional useful information on the tonnage or volume. Additionally, data is collected in the UK and in Helsinki from demolition contractors, with reporting specifically on volumes/tonnage of arisings of different materials classes. London collects good data on local waste facilities, including the type of waste, waste management category, and the volumes of waste passing through the facility; this has been collated into the London Waste Map[7], for which the underlying data is readily available for download.

Overall, data on circular flows is lacking, with very little information in terms of recycling and reuse, and little granularity in terms of destinations and specific types of secondary use. Area-level recycling rate of CDW in Hamburg was identified, though not up-to-date or actively updated. Additionally, no data was identified on the rate of use of recycled or reused materials in construction works.

[7] https://maps.london.gov.uk/waste/

3.1.2. **Accessibility of data**

The accessibility level of data is important in determining how readily it can be used, and by whom (see section 2.1). Open data is readily useable for the types of activities within CIRCuIT.

A fairly large volume of open data was identified across the cities. Most open data identified is top-down data that is collated into centralised datasets and shared by local authorities or government bodies. There are various platforms that index open datasets. For instance, open data for London may be found on London Datastore[8] or MHCLG Open Data[9].

License-only data and data available upon payment is also often accessible where relevant actions are taken, though there may be conditions for meeting license requirements, and the use of such data can be restricted to an extent.

It was also clear from research and discussions with industry stakeholders and academic researchers that there is also a large amount of data which is held privately and currently not possible to view, download or remix in any way. This data is often gathered and held privately with no outward indication that it exists (e.g. as part of contractors' operations). Relevant industry organisations that are likely to have insights into what kinds of private data are collected have been contacted for information, and it is expected that further information will be obtained in future.

Much of the abovementioned non-open data would be highly useful in improving the completeness of picture of a city system's material stocks and flows, particularly upstream and downstream material flows (since it is often standalone organisations that are responsible for material supply and waste/resource management). In cases where relevant data is collected by such organisations it is often held on private databases, inhibiting its utilisation. If centralised and released as open data (with aggregation and anonymisation of data as appropriate), this data would support and enhance commercial and political decision-making relating to the circularity of material stocks and flows in city construction sectors. However, there may be challenges relating to incentivisation, security and legality of the wider sharing of non-open data. Innovative methods and technologies such as blockchain data storage may provide solutions to these issues.

3.1.3. **Granularity of data**

The different datasets identified showed a wide range of spatial and temporal granularity, from single statistical figures on rate of recycling at a national scale to real-time data uploaded to centralised planning systems. The variability in terms of granularity was too great between individual datasets within each city cluster and within each data subject to ascertain any major patterns. Overall, however, the granularity of data tended to be low, with many datasets being updated annually, and relating to a wide spatial area.

[8] https://data.london.gov.uk/
[9] https://opendatacommunities.org/home

Open datasets (largely produced by public bodies) were generally found to present data at broader scales and lower spatial and temporal granularity, such as building stock figures or waste management statistics at the city or borough level.

Note that there are many useful exceptions to this rule, such as the London Development Database which will soon deliver a 'live hub' of publicly accessible data and information on individual planning permission requests, approvals and completes as they are received or issued. On the other hand, there is a significant volume of disparate (i.e. non-centralised) private data collected by upstream and downstream organisations involved in material flow (see sections 2.1 and 3.1.2) that is of a substantially higher granularity, which could be extremely useful if centralised and made open.

3.1.4. Up-to-dateness and active updating of data

A large variability was observed in terms of how up-to-date datasets were and whether they were actively updated, with little pattern in variation. In many cases there was a lag time between the time frame referred to by data and the date of its publication, occasionally of multiple years. Additionally, many datasets were identified that were relevant in terms of subject but no longer updated.

3.1.5. Accuracy and reliability of data

The accuracy and reliability of data is mostly very difficult to ascertain, largely owing to poor transparency in terms of methodology of data collection, analysis and verification. Often, there is only one dataset for a particular data subject within a city – this means that there are often no benchmarks for comparison. No patterns of similarities or differences are obvious between city clusters or between data subjects.

However, it is obvious that there is some significant scope for inaccuracy and unreliability in the data ecosystems. Much data on material volumes or tonnage is based on estimates and assumptions, and allows significant scope for inaccuracies based on human error, double counting and other causes of misreporting. For example, in Copenhagen, data on the Building and Dwelling Register (BBR) is collected by building owners who lack training and expertise in surveying buildings, and very little systematic verification and assurance of this data occurs.

Other data relies on extrapolations from old data, or on broad and unverified assumptions based on related factors such as the economic performance of a particular industry rather than bottom-up data collection. The scope for inaccuracy in such cases is borne out of the fact that any data is not actual observed data, and extrapolations to be inaccurate due to incorrect modelling assumptions.

3.1.6. Standardisation and interoperability of data

There are a large number of datasets on different subjects, which necessarily follow different units and formats. In some cases, even different datasets dealing with the same subject do not use standard units and formats. An additional challenge occurs due to discontinuities in material and product classifications: some data sources use one classification system, while others use a different one, and others use no classification system, leading to uncertainties regarding materials represented in data, and the potential for double counting.

4. Use cases for city data on built environment and material stocks and flows

This section presents a range of 'use cases' for the identified data that have been formulated based on the findings of the data ecosystem mapping carried out as part of WP3 task 3.1. For the present purposes, use cases are defined as ways in which the available datasets may be analysed and combined to yield insights relevant to the project's aims and objectives, and to circularity in the built environment more widely. The following subsections are structured around the requirements of other work packages, however the use cases are intended to provide a general overview of the state of the art in terms of data capture and utilisation, as stipulated in the requirements for deliverable D3.1 to "report on the current best practices and state of the art knowledge and capability in mapping and understanding material flows in the built environment," and to examine the "latest innovation in facilitating material-based mass scanning of the existing building stock". Each section provides overviews of each use case and a basic description of the data requirements.

The structure of this section is based around the work packages in which data will be useful. However, as stipulated in the requirements for task 3.1, it is intended to demonstrate the potential uses for data more broadly. The most numerous and straightforward uses for data specifically to work packages are within WP4 (Urban Mining) and WP8 (Circularity Hub); use cases for WPs 5 (Transformation and Adaptive Reuse) and 6 (Design for Disassembly and Flexibility) are more limited. Meanwhile, WP7 (Governance, Instruments and Urban Planning Tools) will primarily be implementing findings from the other WPs, and so any data use cases elaborated for other work packages could feed into WP7 to be considered as a potential tool for policymakers and urban planners.

4.1. Urban mining and reverse cycles

To achieve the objective of CIRCuIT to demonstrate 20% reduction in use of virgin raw materials in new built environments and cost savings of 15% requires the development of practical solutions to encourage the recovery material outflows from built stock which can replace virgin raw materials. 'Urban mining' sees existing building stocks as repositories from which raw materials can be extracted and used in new use cycles to avoid waste and the further extraction of virgin natural resources (Brunner 2011). The focus of CIRCuIT WP4 is to develop conceptual and practical understanding of urban mining to encourage decision-making that increases and optimises its adoption. Related to this, some key objectives of WP4 are to quantify the likely quantities of materials arising from demolished stock, and to evaluate the relative impacts of circular versus linear routes for these materials, incorporating displacement of virgin resource use amongst other benefits. At city scales, data can be combined, extrapolated and analysed to help guide urban mining strategies by planners, developers, designers, builders, and others involved in construction and demolition. For example, by allowing predictions of quantities and sources of material outflows from building and infrastructure stock segments at the area level, as well as likely requirements

for materials in construction works (which materials sourced through urban mining may be used for). Furthermore, it may be used to evaluate the relative environmental, social and economic impacts of different urban mining scenarios.

4.1.1. Calculating current material stock

Urban mining involves the reclaim and use of materials embodied within the building stock that are 'released' upon demolition or through other works (such as building modifications). To predict the overall amount of material release therefore requires having knowledge of the (estimated) amounts of materials that are currently embodied within the building stock, with the assumption that eventually it will all be replaced.

There are various methodologies available for calculating or estimating current area-level (e.g. borough, city, region) material stock. The following suggested approaches are based upon those encountered in the literature that can be tailored to the data identified in the data ecosystem mapping. Some novel methodologies have also been described.

Note that owing to differences in data availability and attributes, there are methodological variations for calculation domestic versus non-domestic material stocks; Ortlepp et al (2015) provides a good review.

4.1.1.1. *Building-/asset-level materials inventory approach*

A straightforward approach for calculating urban material stocks is aggregating data from databases that contain the volumes of different materials present within each building or infrastructure asset in the area under study. This would provide an area-level total of embodied materials. Unfortunately, none of the city regions under study have specific material volume data at building- or asset-level. However, estimates of material volumes may be made using other methods.

4.1.1.2. *Building-/asset-level material intensity calculation approach*

Where possible, another approach could be to use building- or asset-level data on materials and building or asset design specifications (e.g. wall construction, roofing, cladding and so on for buildings) combined with typical material intensity of these specifications (usually expressed volume or mass of materials per unit area) to calculate each building/asset's total embodied material quantities, which may be performed for each building/asset and then aggregated to yield material totals for a built stock segment[10].

In Denmark and in Finland, building-level data on materials, construction type and building dimensions is available for the entire national building stock, both residential and non-residential, though it may not be available for each individual element. In Finland, for instance, data is usually limited to the type

[10] A building stock segment is defined here as a sub-division of the building stock that is distinct from other sub-divisions in some way. For example, a building stock segment may be all of the buildings within a certain use class, design type, construction type, age, location, dimensions, and so on, or a combination thereof.

of material in the façade and load-bearing structure, and the materials provided are only the main materials. Therefore, calculations are only rough estimations. Building-level data on materials is not currently available for London or Hamburg.

Material intensity data, the other requirement for the present methodology, was identified for London and Hamburg. In London, it can be extracted from the Green Guide (BRE)[11], which provides typical material amounts per unit area for different building element specifications (e.g. external walls, internal walls, roof, ground floors, upper floors, windows and so on) in different building types (e.g. domestic, commercial, industrial). A German report[12] details typical tonnage of different materials per m^3 of different building ages and construction types. Additional sources may be found in (Heeren & Fishman 2019), who compiled a database of studies reporting material intensities for buildings, with the UK and Germany represented, but not Denmark or Finland[13]. Ultimately, no material intensity data was identified for Helsinki or Copenhagen.

Some relevant data on infrastructure asset dimensions are present for all cities to an extent (though this data is mostly held privately by contractors, transport authorities, utilities authorities and the like); material intensity data which may be applied to dimensional data to yield material quantities was not found.

With the above sources of data, the next step would be to sum the total area of each construction specification of all buildings in the building stock or area under study, and apply the material intensity calculations to achieve stock- or area-level material quantities. For examples of using this approach in building stock, see Stephan and Athanassiadis (2017), Tanikawa and Hashimoto (2009), and Ortlepp et al (2015; for non-domestic building stock in Germany).

4.1.1.3. *Typology-based approach*

Where building- or infrastructure asset-level material contents, construction types or dimensions are not known (as in the case of London and Hamburg), it may be possible to follow a typology-based approach. This involves obtaining or calculating the typical quantities of materials within a range of common building types, which are distinguished from each other according to factors such as age, use class, construction type, and so on. From this, the material totals for the area under study may be calculated based on the number of instances of each building type within it, multiplied by their respective typical material quantities. This approach has been used in several studies, such as Bergsdal, Bohne, & Brattebø (2008), Schiller (2007), Kleemann et al (2016a) and Kleemann et al (2016b). Note that no typologies for infrastructure assets, or information from which they may be created, was identified.

[11] BRE Green Guide to Specification https://www.bregroup.com/greenguide/podpage.jsp?id=2126

[12] Baufachliche Richtlinien Recycling: Arbeitshilfen zum Umgang mit Bau- und Abbruchabfällen sowie zum Einsatz von Recycling-Baustoffen auf Liegenschaften des Bundes (available at https://www.fib-bund.de/Inhalt/Richtlinien/BFRRecycling/BFR_Recycling_2018.pdf)

[13] The purpose of Heeren and Fishman's article was to report on the creation of a community-driven material intensity research platform – this should be monitored and contributed to where appropriate as part of relevant CIRCuIT workstreams.

For some countries, including Germany, typical material quantities for different building typologies have already been calculated, and so these may be readily fed into the above methodology (Ortlepp et al 2015).

In the case of London, the typical dimensions and construction types of the most common house and commercial building types in the UK were compiled as an (unpublished) output of the Buildings as Material Banks (BAMB) project[14], and are also possible to derive from English Housing Survey data compiled by BRE. The TABULA and EPISCOPE[15,16] projects, as well as a number of individual research studies, compiled residential building typologies for other EU countries including Hamburg, and it is known that typologies have been used in Material Flow Analysis studies for Finland. While material quantities are not provided as part of the abovementioned sets of building typologies, it is possible to calculate them using elemental material intensity data (i.e. data on the material intensity of building elements), where construction type is known. The material quantities of different typologies may then be scaled up to the area-level using building stock data on the numbers of each building typology. Building stock data exists in all city clusters, and generally segments figures by building characteristics that could indicate the typology of the building, including age, use class, number of bedrooms, form and dimensions.

To improve the accuracy of the abovementioned methodology, it may be possible, where relevant data is available, to model the effect of variability in building dimensions and life histories (e.g. tenure or refurbishments/retrofits undertaken) on material quantities for different typologies. This would require data on typological characteristics and material contents data taken from a sample of buildings from which a model may be derived. For London, the English Housing Survey collects high-quality data that meets these requirements.

Note however, that the most complete building stock data is on residential buildings; commercial, industrial, retail and other building uses can have incomplete data. Additionally, there will be a degree of error due to the fact that many buildings will deviate significantly from any standard typologies. Furthermore, building typologies may be nationally-representative despite regional variation. For example, a three-bedroom semi-detached house in a dense inner-city neighbourhood may be built to be more compact than the nationally average three-bedroom semi-detached house. The accuracy of typologies may be improved by obtaining median values (for dimensions) and mode values (for element material classifications) from a larger sample of representative buildings for each building type.

4.1.1.4. *Inferring material quantities from built volume and surface area*

Another approach to calculating embodied materials stock is using 3D buildings data (e.g. OS Building Heights[17] in the UK, LIDAR data) to calculate the built volume and surface area of walls, roofs and floors. This can then be

[14] https://www.bamb2020.eu/
[15] https://episcope.eu/welcome/
[16] BRE, 2014. BRE Building Typology Brochure, England. For EPISCOPE project. http://episcope.eu/fileadmin/tabula/public/docs/brochure/GB_TABULA_TypologyBrochure_BRE.pdf
[17] https://www.ordnancesurvey.co.uk/business-government/products/mastermap-building

combined with other building-level data to calculate material quantities. This approach may be relatively straightforward where building-level material contents data exists, such as Copenhagen. In other cases, building-level data exists that would be indicative of the building typology, such as construction type, age, use class and number of floors, and therefore the likely materials quantities can be estimated (see section 4.1.1.3). See Mastrucci et al (2016) or Ajayabi et al (2019) for examples of this methodology. Also see Steadman, Hamilton & Evans (2014), who created a 3D map of London using OS building footprints data overlaid with LIDAR data to model building heights.

In London, the Greater London Authority and University College London are developing the London Building Stock Model (LBSM), which is intended to be a 3D map of London including building-level EPC data. Though it is still under development, the LBSM may become a useful source of integrated geolocated data for the purposes described here, once the data can be accessed.

In the case of infrastructure, the lack of material intensity data prohibits this methodology from being applied. It is recommended that research is carried out from which typical material intensity of different typologies of asset and specifications can be made.

4.1.1.5. *Computer vision techniques*

Computer vision techniques may be incorporated within each of the previous approaches. ‘Computer vision’ pattern recognition algorithms can be used to identify the number of buildings of each typology within an area using street-level image data (e.g. Google Street View or crowdsourced images), remote sensing data (e.g. satellite imagery, airborne LIDAR), land use data, or other map data (Ibrahim, Haworth & Cheng, 2020). Similar methodologies have been used in academic research to find and quantify prevalent building types within a study area, as well as to draw further insights on biophysical and social dimensions of place (e.g. Nguyen et al 2018; see also Kang et al 2018). An emerging capability of computer vision is the recognition and quantification of dimensions, design specifications and material content of buildings based on factors such as texture and form within imagery, which may help to improve the accuracy of classifications (Dimitrov & Golparvar-Fard, 2014; Yang, Shi & Wu 2016).

4.1.1.6. *Other approaches*

Researchers have previously derived estimates for urban material stocks by determining correlations between known urban material stocks and area-level characteristics such as Gross Domestic Product per capita or remotely-sensed nighttime light intensity. These correlations are then applied to areas where material stocks are not known (Lanau et al 2018; see e.g. Takahashi et al 2010). While this may be useful for making high level estimates, such as at national and global scales, it is unlikely to involve the degree of granularity, accuracy and reliability that is required for decision-making (Lanau et al 2018).

4.1.2. Calculating materials release at current demolition rates

One of the activities in WP4 is to identify building stock segments with the highest rates of demolition upon to serve as a target for pre-demolition audits. To do so requires having data on the numbers of buildings within different building stock segments that are demolished each year, for each city cluster. Data on demolitions is available in Helsinki/Vantaa and Copenhagen through demolitions registers; in Hamburg, demolitions data is held by sub-city local authorities rather than the city authority, and is mostly held as physical paper records; in London, some demolitions are registered through the planning system, though this data is not readily extractable from the data. Additionally, only a subset of all planned projects eventually go ahead.

4.1.3. Predicting future materials release rates

Exploiting opportunities and designing policies surrounding urban mining will require more than just an awareness of the total material stock within a building stock; the current building stock is modified and replaced gradually over the course of multiple decades. Understanding the relative rates of release for different materials at different times will help guide more precise, targeted decision-making.

Material release over a given time period will primarily rely on two factors: (a) the rate of works, i.e. the number of buildings or infrastructure assets to undergo construction, modification and demolition works, within that time period, multiplied by (b) the typical amount of materials released from those buildings and assets through the different types of works.

4.1.3.1. *Predicting rate of works*

Various studies have developed methods to estimate the future rate of demolitions. One option is to carry out a survival analysis of building stock, using information on their ‘mortality’ as indicated by their attributes (such as age and use class) and the contextual factors influencing their survival or demolition. Historical demolitions data is used to ascertain patterns of typical age at demolition of different building types, and the circumstances preceding demolition (Muller 2006; Bradley & Kohler 2007; Tanikawa & Hashimoto 2009; Sartori et al 2008). The resulting patterns in mortality and survival of certain building types may then be extrapolated to the future based on the representation of building types within the current building stock, where this is known. Using historical data on Finnish demolitions, Huuhka & Lahdensivu (2016) identified that demolition rate at the national level for Finland was linked with demographics (population size), new construction rate, urbanisation, and size of settlement; to a lesser extent also with building age. From these findings they derived projections of the demolitions rate for Finland to 2100. All of the methods mentioned require some historical data on demolitions. Unfortunately, aside from Finland, demolitions data is typically scarce (including in the CIRCuIT city clusters). One potentially novel solution to fill this gap is to perform change detection analysis, whereby historical remotely sensed data (e.g. satellite imagery, airborne LiDAR), building footprint data, or street-level image data is compared with more recent data and analysed for changes using machine learning algorithms

(e.g. Alcantarilla et al 2018; Che & Gamba 2018; Kleemann et al 2017; Zhu et al 2020; Tran, Ressl & Pfeifer 2018). Where previously standing buildings and infrastructure are no longer in place, they may be assumed to be demolished. Note that this technique can also be used for new construction and building modifications.

Future building modification rates of different building stock segments have been predicted in the literature based largely on *a priori* assumptions (e.g. Sartori et al 2008; Sandberg, Sartori & Brattebo 2014). Often, based on future needs based on building deterioration and demand for increased energy efficiency, it could be assumed that the rate of modifications will increase. A more empirical method would require some data on numbers of building modifications – this is largely absent, though promising sources look to be emerging, such as the Trustmark Data Warehouse in the UK, to which installers of home energy retrofits installed under Energy Companies Obligation (ECO3) scheme upload data on the building characteristics and the measures installed. Overall, prediction of modifications rate is difficult currently due to a lack of data; any data that does exist tends to be highly disparate and does not cover the extent of a city or region's total works of that type.

4.1.3.2. *Typical material release rates from different typologies and construction works*

Different materials will be released in different quantities according to features of the building and the type of construction works undertaken. Consequently, at the level of regional or local building stock, the rate of material release will depend on the different works being undertaken on different typologies within the building stock.

Typical material release from demolition is generally taken to equate to the materials embodied within the building being demolished, and as such material release from demolition for a given area may be approximately determined by multiplying the predicted number of demolitions within the area under study (see previous section) by typical material contents of those building typologies (see section 4.1.1.3). Material release from building modifications will depend on the type of modification and any building elements that are replaced. There is currently no good data on which building elements are replaced and to what extent.

An alternative, and likely more accurate, method would be to use data on observed typical materials release from different building types undergoing different works. In London, such data is available through the SmartWaste[18] platform. SmartWaste is widely used by project teams to monitor and record data on the quantities of various waste classifications arising from the project site. As part of this process, data is also collected on the characteristics of the project (i.e. building type, works undertaken). This data can be aggregated to generate the typical material release of different building typologies undergoing different types of construction works. Ultimately, this information may be combined with the data on numbers of building likely to

[18] SMARTWaste - https://www.bresmartsite.com/products/smartwaste/

undergo different works to yield estimates of materials release for a given time period. Unfortunately, no similar platforms were found for other cities.

A less granular approach which may however be more feasible for other city clusters due to the existence of relevant data, could be to utilise existing data on national, regional or municipal waste generation rates, analysed to determine the influence of directly-related predictors such as demolition rate and new construction rate, where these are known. The resulting model may be used to forecast area-level waste arisings using, where available, projections of any factors found to be influential.

4.1.3.3. *Broader prediction of CDW as a proxy for material release*

In a similar approach to that previously described, material release may also be inferred via the less granular approach of using forecasts of known predictors of construction and demolition waste (CDW), which can be taken to be a proxy of the release of materials available for urban mining). For instance, Menegaki and Damigos (2018) found that per capita CDW (all waste classes) was significantly predicted by GDP per capita, construction GDP (amount of GDP resulting from construction) and population density, such that a rise in any of these predictors is strongly associated with a rise in CDW. Where projections data is available, the same approach could be used to model future CDW based on the future values of these three predictors. Similar analyses could make use of other economic metrics, as well as social and demographic metrics such as population growth, class mobility, and age structure. While projections data is available on many such predictors in CIRCuIT host countries (and, in some cases, cities and sub-city municipalities), there is a degree of uncertainty within these projections.

Of course, the actual quantities and condition of different waste classes is likely to vary, and this approach is not granular enough to enable such prediction, however it may provide a broad picture of overall material release under different projected social and economic scenarios.

4.1.3.4. *Considerations*

While the approaches described in this section do not take into account local-level factors such as local planning policies, climate change or stochastic events such as extreme weather, there is data and information on some of these factors which may be codified and against which factors such as building stock overheating and flood resilience may be weighed to improve the accuracy of models.

4.1.4. **Predicting near-term material release using planning data**

An alternative approach to assessing material release for urban mining for a given area is to use planning data. Planning permission is generally required for works of a certain scale (whether new construction, modifications to an existing building, or demolition), and in many cases requires providing an indication of waste arisings, though these are generally expressed through qualitative descriptions rather than numerical data using standardised units and formats. However, where quantitative standardised data is available, it

may be possible to aggregate this data to the area-level (e.g. city, district, neighbourhood) to yield estimated quantities of material release.

Note, however, that demolition activity does not always require planning permission to undertake, such as in the case of residential demolitions under UK planning laws. Additionally, planned projects are often not completed within the permitted time frame. A more appropriate source of data here would therefore be projects which have been recently started, which may be used to calculate a near-term forecast of material arisings. Prior to commencement of works, a project in England will generally have to submit a Commencement Notice to the local planning authority; the same is true for Hamburg, Helsinki/Vantaa and Copenhagen. These may be used as a screening methodology to ensure that data is captured on projects that are to begin in the near future.

London, Copenhagen and Helsinki demonstrate examples of collecting data that may be useful for the present use case. In London, a new planning requirement for Circular Economy Statements (due to come into effect in 2020) will mean that projects must provide, amongst other things, pre-demolition audits, a bill of materials informing material intensity and predicted volumes of waste data for the project, in quantitative terms. Concurrently, the recently developed London Development Database (LDD) is in the process of becoming a “live hub” which will receive planning data directly from borough planning databases through API. The data on the LDD will have an open licence, meaning it will be possible to freely download and use up-to-date planning data for the whole of London that is spatially and temporally granular. Therefore, if quantitative data from Circular Economy Statements is fed into the LDD live hub, the methodology in the previous paragraph may be used to predict near-term material arisings from recently commenced projects. The London Waste Map[19] shows the location and tonnage information for all waste sites with an environmental operations permit. The ambition is for the map to help identify suitable sites that could be transformed to act as material banks and meanwhile sites supporting materials flow data provision.

In Finland, a permit and/or notification of a planned demolition is required before carrying out demolition works – this remains valid for three years (where a building permit includes demolition of an existing building, no demolition permit is needed). Planned demolitions are generally recorded on a demolitions register, which provides details on estimated waste arisings. This data may be aggregated in the same way as described above to provide area-level data on materials release for urban mining.

Denmark also requires the completion and submission of predicted waste volumes for the project upon demolition. However, these are noted to be uncertain and as such the data may be somewhat unreliable.

Note that in some planning systems, “permitted developments” – i.e. works of below a certain scale or of a certain type – do not require planning permission. Additionally, across all countries, planning permission is in many cases not sought for some projects where it should be. Consequently, there

[19] https://maps.london.gov.uk/waste/

may be significant amounts of material release that a methodology based on planning data does not capture.

4.1.5. Secondary use rates of end-of-service-life materials

Understanding the volumes and relative proportions of the pathways (i.e. reuse, recycling, energy recovery, landfill) taken by released materials at end of service life (EoSL) from different building typologies would be useful for assessing where the lowest rates of diversion from landfill are occurring, and could be used to inform the creation of policies and the exploitation of commercial opportunities in material and product recovery. Additionally, where circularity data exists, a degree of specificity as to the exact next uses would be useful; while around 90% of CDEW (construction, demolition and excavation waste) is reused or recycled in the four CIRCuIT host countries, a significant majority of this is used for backfilling operations despite many higher-value options being available, and little makes it back into the building stock.

While no systematically updated datasets exist on typical EoSL pathways for released materials is available for any of the cities, estimates may be made using aggregated data from platforms such as SmartWaste. These platforms allow project teams to monitor and benchmark the quantities of waste arisings, split by waste class and destination (including circular routes). While SmartWaste is only widely used in London, and there only on a minority of the overall building stock, a handful of studies have been undertaken in the other city clusters which may indicate typical EoSL pathways[20].

An important factor in increasing built environment material circularity is the reusability or recyclability of the materials that are released. If the circular potential of the materials embodied within building stock is known, then the impacts on the economy's demand for new materials and on waste flows can be modelled. However, there is currently no data that assigns "reusability scores" or "recyclability scores" to released materials or products based on their inherent ease of reintegrating into the building stock. Useful methods here would include 'circular building assessments' which assign a circularity score to individual buildings based on their design and construction specifications, as well as an enhanced understanding of the reusability/recyclability of individual material classes once they are released from the building stock.

4.1.6. Calculating relative economic and environmental impacts of urban mining scenarios

One potential use for material release information is to calculate the estimated economic and environmental impacts of its redirection to various circular pathways over landfill, and to design optimal policies and commercial strategies around this.

[20] See e.g. Keikka Project (Helsinki; link); Statistisches Amt für Hamburg und Schleswig-Holstein, 2018 (Hamburg; link); Ministry of Environment and Food (Copenhagen; link)

At the building level, the Buildings as Material Banks (BAMB) project undertook pilot projects which measured the embodied CO_2 reductions for various types of design and construction allow building reversibility. The results of such studies may provide an indication of the CO_2 savings achievable under different scenarios of urban mining (Capelle et al 2019).

At a wider scale, Wu et al (2016) carried out the above for the city of Shenzen, China, using a combination of Geographical Information System (GIS) and life cycle assessment (LCA) methods, and were able to model the environmental benefits of various recycling rate scenarios for future demolition waste streams, based on predictions of demolition rate (using methods akin to those in section 4.1.3). Drawing on recycled material market rates provided by recycling industry stakeholders, they were also able to model the economic value of different recycling rate scenarios.

Similarly, Mastrucci et al (2017) used LCA-based methodology to compare a modelled 50% inert demolition waste recycling scenario with a 70% one in the town of Esch-sur-Alzette, Luxembourg, finding that the higher recycling rate led to reductions in abiotic depletion potential and global warming potential of 25.6% and 9.2% respectively.

To undertake the above analyses requires firstly material stock quantities for the area under study; secondly end-of-life data on disposal (environmental comparisons) and/or market value data (economic comparisons); and thirdly an LCA methodology. With adequate data, the approach could theoretically be extended to allow modelling of multiple EoSL scenarios, including different rates and combinations of reuse, recycling, energy recovery and landfill, of different materials. This could be useful for predicting the likely impacts of policies and interventions.

Data on market value of reclaimed materials and products is scarce, which has meant assumptions may have to be made when assessing the value of recycling of released materials (e.g. Ajayabi et al 2019). This lack of data remains mostly true for the CIRCuIT city clusters, though figures from waste exchanges such as Salvo[21] and waste brokers such as Reconomy[22] may serve as an approximate indicator of market prices. Additionally, there are some outdated or more anecdotal sources of information that could serve to indicate market rates.

4.1.7. Forecasting material requirements in future construction

An important aspect of urban mining, which is related to the previous sections on EoSL scenarios and their relative environmental impacts and economic values, is future demand for any materials that may be released. If released materials go unused or underused, they represent missed opportunities for conserving value and reducing demand for natural resource extraction. Forecasting future demands for different materials could allow decision-makers to analyse which material stocks are likely to be most valuable and environmentally beneficial to consider for urban mining.

[21] https://www.salvoweb.com/
[22] https://www.reconomy.com/

Various studies have developed methodologies for forecasting material requirements in building stocks under the umbrella of Dynamic Material Flow Analysis. Muller (2006) constructed a model for concrete requirements in the Dutch dwelling stock based on data on population size, useful floor area per dwelling, persons per dwelling, useful floor area per capita, (assumptions of) dwelling lifespan distributions, and concrete intensity per unit of useful floor area. The model was then used to create scenarios for concrete requirements up to the year 2100. Various studies have since adopted similar approaches (e.g. Bergsdal et al 2007). Sartori et al (2008) developed a method to predict the rate of construction and renovation as well as demolition for Norwegian dwelling stock to 2100, based on population and socio-economic data (e.g. persons per dwelling, average dwelling size), from which demand for concrete and wood were predicted.

More bottom-up approaches may make use of data on the conditions and contexts that determine the need for repair/refurbishment or building abandonment. For instance, the relative prevalence of different types of disrepair or substandard conditions within different building stock segments, combined with data on the relative costs of repair, refurbishment and new construction may indicate the likelihood of works to a building, or its abandonment (and hence the new construction of a building with a similar function).

Estimating future requirements for non-structural materials required in repairs, replacements, refurbishments and so on is trickier to achieve. Researchers developed a method to estimate requirements for non-structural materials (e.g. plasterboard, carpet, ceramics) from 2018-2030 in the building stock of Melbourne, Australia, based on data on the representation rate of typologies within the building stock, combined with a database of typical material service lives (Stephan & Athanassiadis 2018). Data on material quantities in different typologies is often available or possible to derive from existing data sources (see section 4.1.1.3). Data on material service lives have been developed in some (non-European) studies based on heavy assumptions, as in the case of the abovementioned study; similar methods may be used to generate material service life assumptions for the purposes of the present approach.

4.2. Extend lifecycles through transformation and refurbishment

The principal aim of WP5 is to “facilitate the sustainable transformation of the building stock through adaptive reuse and refurbishment of existing buildings and agglomerations of those buildings, i.e. neighbourhoods and cities”. A key aspect of this is to develop “evidence-based systematic methodology to identify obsolete and transformable buildings and neighbourhoods, and to use these methods to select specific demonstration cases”; this is the focus of Task 5.1.

4.2.1. Identifying and predicting obsolescence in the building stock

Obsolescence in the context of buildings and infrastructure is defined as the point at which the asset no longer meets performance requirements, becoming unfit for purpose (Thomsen & van der Flier 2011). To develop

insights on how to extend building lifecycles and avoid demolition first requires an understanding of rates of obsolescence for different building stock segments within each of the four cities, and whether these rates are likely to increase over time. With this information, the building stock segments that are most likely to be demolished may become the foci for innovation and policy interventions relating to transformation through lifecycle extension and adaptive reuse, or waste minimisation strategies that make the most of urban mining techniques as a last resort. Additionally, understanding the factors in obsolescence can help designers and planners to avoid pitfalls.

Obsolescence in buildings can occur for a number of reasons, which may be broadly classed as either physical factors (e.g. physical deterioration or health concerns of materials), and behavioural factors (e.g. tenure, changing levels of affluence, changing cultural preferences for features and aesthetics, changing use requirements). Additionally, they may be classed as either endogenous (occurring due to inherent characteristics of the building) or exogenous (occurring due to factors external to the building) (Thomsen and van der Flier 2011). These processes often lead to buildings becoming abandoned or underused, and often demolished to make way for new construction, with the displacement of potential building users directly or indirectly leading to increased demand for new construction. Note, however, that obsolescence does not always result in demolition, and demolition is not the result of obsolescence alone, though it is a strongly contributing factor (Thomsen and van der Flier 2011).

At present there has been relatively little empirical research dealing with identifying and classifying obsolete building stock segments, largely owing to a lack of data. One line of research developed and validated a checklist of physical, economic, functional, technological, social, legal and political building characteristics which indicate building obsolescence, and from which adaptive reuse potential can be modelled (Langston 2008; 2011). The checklist relied upon for these studies, however, cannot be completed from current area-level or stock-level buildings data, since it requires data that can only be gathered through extensive research into individual buildings (as was completed for the studies mentioned). For example, questions include “Was the workmanship standard for the project high?” and “Is a building manager or caretaker usually present?” – these clearly cannot be answered for a building stock, and so prohibit this methodology from being applied en masse.

An alternative route to identifying building stock segments that are at risk of obsolescence *en masse* could involve using proxies for obsolescence such as demolition rate and building abandonment rate. Where such information is available, the common factors of buildings experiencing a higher rate of demolition or abandonment could be identified and quantified, and then the prevalence of these predictors and combinations within the current building stock could be used to derive estimates of the numbers of buildings at elevated risk of undergoing demolition or abandonment. Examples of predictors could include building attributes such as use class, age, specifications and tenure, as well as local contextual factors such as affluence, market conditions, and behavioural or aesthetic preference changes. The relative impacts of the abovementioned predictors on demolition or abandonment may be quantified by creating a predictive

analytics model (e.g. through regression analysis) using historical datasets of predictors and outcomes. The resulting model may then be applied to current building stocks to help identify at-risk segments based on the relative prevalence of predictors within those segments.

There are a range of data sources that could be useful for these purposes. Historical building abandonment rates are scarce – while data on vacancy rates are common, a significant proportion of these may be second homes or investment properties rather than building abandoned due to obsolescence. Historical demolitions data is available for Helsinki, Copenhagen and Hamburg, though its comprehensiveness, accessibility (in the case of Hamburg), and fitness for the presently described purpose may not be adequate due to a lack of relevant information on the purpose of the demolition. Demolitions data is not available for London. However, where demolitions data is scarce or absent, there may be potential for derivation of demolition rate through change detection analysis (see section 4.1.3.1).

An additional factor indicating obsolescence could also be the rate at which new buildings of a certain use class are added despite there being vacant buildings of the same use class, which would suggest that those left unused are now unfit for purpose for some reason. It is not known how this could be integrated into a predictive model.

Predicting the numbers of buildings that are likely to become obsolete in future may be achieved by constructing a model based on current and historical demolition and vacancy rates of different building segments. The predictive capabilities of such a model may be achieved using historic data on a range of contextual factors (e.g. demographic and population change, building user trends, climate change) to determine their role in demolition and vacancy rates, and then adding projections data for the same contextual factors to the model. Additionally, new spatial planning strategies (such as ‘Intensification Areas’ in the London Plan, London’s spatial development strategy) and any concomitant changes to planning policy can mean that buildings become obsolescent due to incentives for developers and local authorities to alter the profile and function of building and infrastructure stock in that area, though the quantification of the impacts of these on likelihood of obsolescence is likely to be difficult and case-specific.

4.2.2. **Assessing transformation potential**

Where buildings have become behaviourally obsolete (see above section) but are likely to remain physically sound for some time, transformation through adaptive reuse and refurbishment presents a way to optimise resource efficiency by meeting building demand without the need for demolition and new construction.

There are various ways in which data could be used to guide decision-making regarding adaptive reuse.

Firstly, it may be used to indicate the current and future patterns of demand for different combinations of building characteristics, to help define the type of buildings that the current obsolete stock should be transformed into. This

may be achieved either by analysing the extent to which factors influencing the rate and feasibility of adaptive reuse are expected to exist (Langston 2008; 2011), though suitable data may be difficult to obtain. The requirements of strategic development plans for the area (such as London's Intensification Areas) could also be highly useful to indicate the need for built functionality.

The transformation potential of a building stock segment is likely to rely on a range of factors, including the presence or absence of certain critical features (such as structural robustness), the practicality and profitability of adaptive reuse options, and a supportive local context.

There was no relevant data identified upon which an assessment of transformation potential could be achieved, since it is largely dependent on individual building attributes for which there is little or no data collection. However, a potential proxy for the transformation potential of a building stock segment may be achieved by using historical data on building transformation rates (operationalised as major building modifications and/or changes of use within planning data), weighed against obsolescence rates (as described in the previous section). Hypothetically, a stock segment with high obsolescence rates and low transformation rates may be assumed to be either impractical or economically less profitable to transform, while one with low obsolescence and high transformation rates is likely to present good opportunities for transformation. One caveat with this methodology is that in some cases, significant materially-intensive works may be completed on buildings without planning permission (such as in the case of former office blocks being converted to flats in the UK, which often does not require planning permission under permitted development rules). Additionally, there are likely to be building stock segments with low rates of transformation AND low rates of obsolescence simply because they are fit for purpose as they are, though this would signify that they are not a priority for transformation efforts.

The methodology discussed in this section would not, however, take into account any emerging practical methods for avoiding obsolescence through transformation, which would mean that whole building stock segments that historically showed low transformation rates would be classed as having low transformation potential despite the new methods.

It is accepted, additionally, that there may be methodologies available in the literature that were not identified; these should still be actively located and explored as part of WP5.

4.2.3. Environmental, economic and social costs and benefits of transformation versus demolition

A principle aim of WP5 is to evaluate and replicate the potential impacts of transforming buildings, and scaling this up to the city level. In many cases it will likely be preferable to transform buildings to avoid waste arisings and resource requirements for new construction, though there may also be scenarios where the relative impacts are not known. Empirically-based decision-making will be vital in such scenarios to ensure an optimal outcome (Thomsen & van der Flier 2009). To provide an empirical method of

identifying the environmental and economic costs versus benefits of adaptive reuse over demolition or disassembly, it may be possible to use LCA-, LCC- and social assessment-based methodologies to compare adaptive reuse scenarios versus demolition or disassembly, by weighing the impacts and value of the resources required for building transformation over those required for demolition/disassembly and new construction.

This methodology would require information about the quantity of materials that would be released in either scenario (demolition, deconstruction, adaptive reuse[23]); where this is known, it could be built upon the same methodology described in section 4.1. It would also require data on the characteristics of the building stock to be demolished/transformed and those of the new/transformed stock. Finally, information would then be needed on the social and economic values of the different modelled scenarios according to the relevant characteristics and combinations of characteristics; there are various sources which may be utilised to this end (see e.g. Hosseinjou, Mansour & Shirazi 2014; Wilkinson, Remoy & Langston 2014). In particular, the SAVE Methodology[24], which is widely used in Copenhagen and is available elsewhere in Europe, provides an assessment and certification standard for the architectural value and heritage of buildings.

4.2.4. Additional information and considerations

- While there are possibilities for using data to better understand obsolescence risk and transformation potential at large scales, it is probable that there would be significant margins of error when using the approaches described above due to major assumptions and uncertainties stemming from inadequate data. Consequently, the predictive capabilities of the resulting models are likely to be limited, and any results would be necessarily coarse in the absence of better data.
- As a method of assessing ease of disassembly of a building and the circularity of its constituent materials and components, circular building assessment (CBA) and pre-demolition audit methods (see sections 4.6.2 and 4.6.3) would significantly improve the ease of performing the analyses described above.

[23] Figures for demolition may be obtained from methodologies as described in section 4.1.3, though these are not necessarily accurate; there are no reliable figures for materials released specifically under specific adaptive reuse or building disassembly scenarios.
[24] Description available in English at: https://www.slks.dk/fileadmin/publikationer/Kulturarv/InterSave_english.pdf

4.3. Design for disassembly and flexible construction

WP6 is predominantly intended to identify and address barriers and opportunities for design for disassembly (DfD) and flexible construction, and to develop and showcase practical methods at the building level, with results eventually utilised in decision-making by industry and policymakers.

To frame these activities, data on the extent to which DfD and flexible construction are currently represented in the building stocks of the city clusters would be useful, however none was identified. One potential remedy for this lack of data could be through the increased use of Circular Building Assessment methodologies (see section 4.6.3).

Aside from this, the results of some use cases elaborated within this report may be useful for providing context to the activities of WP6. For instance, projections of future material release from different built stock segments (as elaborated in section 4.1.3) may be useful for determining the types of demonstrations that would be most relevant and impactful. Additionally, the comparative city-, borough- or neighbourhood-level LCA/LCC between high-circularity and low-circularity patterns in urban material release may serve to highlight how hypothetical uptake scenarios (i.e. different proportions of new construction) for buildings designed for disassembly and flexibility may result in different environmental and economic impacts.

Finally, the recent publication of ISO 20887[25] provides “an overview of design for disassembly and adaptability (DfD/A) principles and potential strategies for integrating these principles into the design process,” which is likely to be useful in WP6 activities, as well as guidance on measuring performance of DfD/A which may create data streams in future.

[25] ISO 20887: Design for disassembly and adaptability — Principles, requirements and guidance https://www.iso.org/standard/69370.html

4.4. Governance, instruments and urban planning (WP7)

WP7 is structured slightly differently from the other WPs in that, rather than having new use cases developed under it, the work package will take recommendations from WPs 4, 5, 6 and 9 – some of these will relate to the uses of data explored within those work packages.

While it is still early to make any specific recommendations relating to governance, instruments and urban planning based on the data ecosystem mapping, there are some ways that the findings of task 3.1 may be utilised.

4.4.1. Data capture improvements needed

Any targets, benchmarks, and interventions relating to improving the circularity of built environment materials should be empirically-based rather than dependent on *a priori* hypotheses, requiring accurate and precise data on the stocks and flows of these materials, as well as any linked social, environmental and economic outcomes. In all cities, the impression based on the data ecosystem mapping conducted so far, is that there is a significant degree of missing or poor-quality data. Therefore, it is recommended that authorities make efforts to improve, collate and visualise relevant data across their jurisdictions as completely and in as much detail as possible.

A useful way to achieve this may be, in the same way as the data ecosystem mapping conducted for the present task 3.1, to create a conceptual model of all points across material lifecycles where materials are physically or logistically handled by stakeholders, and to ensure that bottom-up data is collected and centralised in as much detail as possible on all possible points of material flow or stocks. The data should be expressed in standardised units and formats, and should relate to standardised classes of materials and waste to maximise interoperability of datasets. Ultimately, this would allow Material Stock and Flow Analyses, and visualisations thereof through tools similar to the Circularity Atlas (see section 4.5.2) upon which policy and planning decisions may be made.

For much of a city's material stocks and flows, it is likely that no useful data collection – even privately – is taking place. These instances should be mapped and efforts should be made to encourage data collection.

Additionally, based on the results of investigations undertaken for London, a large volume of useful data is being collected by disparate stakeholders who hold the data privately for use as part of their operations. For instance, supply chain organisations may gather data on the number of units of their products sold within a certain area; in Hamburg, sub-city local authorities hold paper records of demolitions. If this data were securely collated, aggregated, anonymised and then shared by city/regional authorities (and/or protected through mechanisms such as blockchain), this could help to bridge the prominent data gaps in supply chain material flows. The same could theoretically be achieved for other gaps in material stock and flow data where private data collection is taking place.

4.5. The Circularity Hub (WP8)

The Circularity Hub is intended to be an open, accessible data and information platform to support acceptance and implementation of circular construction projects by providing stakeholders with actionable information about the circular economy as it relates to the built environment.

4.5.1. Materials Exchange Portal

The Materials Exchange Portal (MEP; task 8.3) will be, in brief, an online marketplace for materials released from the building and infrastructure stock, supporting urban mining approaches explored through the present task (task 3.1) and WP4. Many materials released from built stock at EoSL are not utilised as efficiently and valuably as possible; the MEP is therefore intended to fill this gap by efficiently matching material arisings with material requirements on construction projects.

The Task 3.1 workstream identified active datasets on material release that could serve as sources of material and product listings on the MEP (given data owners' consent to share data and willingness for materials and products to be posted), as well as insights that may help guide the design and delivery of the MEP.

According to the task 8.3 description, the first stage of achieving the functionality of the MEP involves the aggregation of data and examples of practice from existing material exchange platforms.

Existing materials exchange platforms allow individuals, companies and organisations to share information about waste materials that they have generated through their activities, that they either give away free or as a financial transaction. A number of different waste exchange websites exist globally but there are very few specifically created by cities within the Circuit project; examples of these are listed in Table 1 below.

Table 1: Existing materials exchange platforms

Materials exchange online platform name	**City / Country**	**Description**	**Link**
Enviromate	UK	Based in Folkestone Kent, Enviromate was founded in 2015 in order to disrupt the construction and DIY sectors by providing an online platform for the reuse of surplus and leftover building materials.	https://www.enviromate.co.uk/about-us#contact
Construction Material Exchange	UK	Created by Zero Waste Scotland in November 2012 the Construction Materials Exchange tool allows companies / projects to post materials online that can be exchanged with another party for re-use to reduce materials sent to landfill.	http://cme.resourceefficientscotland.com/
Exchange for recycling materials in the construction sector (RBB)	Austria	An online platform established in 2009 allowing supply and demand for recycling CDW to be matched.	http://recycling.or.at/rbb/cake_rbb/
Announce	Czech Republic	One of a number of waste exchange sites within the Czech Republic allowing the exchange of materials such as soil, stones, bricks, windows and tiles among others.	https://dum.bazos.cz/okna/
Clean way Ltd	Hungary	A complex map application that displays produced CDW from projects under construction and in planning stage across Hungary. The application displays available quantities and quality of CDW, including laboratory test results. The forecasted CDW is also displayed to allow resource efficient planning for future projects.	http://www.cleanwaykft.hu/en
WasteChange.com	Europe and North America	Based in Salt Lake City, USA this is a web-based platform that consolidates an international network of local and regional exchange networks to be searchable from one site.	http://www.wastechange.com/
California Materials Exchanges (CalMAX)	California	An online portal established to help connect businesses, organisations and individuals with a number of links to other online resources for exchanging materials.	https://www.calrecycle.ca.gov/calmax
FreeCycle.org	Worldwide	A global network of 5,323 groups in 110 countries founded in 2003 with local volunteers to moderate the online exchange of items for free that would otherwise go to waste disposal. There are approximately 43 active freecycle groups in London registered on the website. Not specific to construction materials; most listings are of household items such as furniture.	https://www.freecycle.org/browse/UK/London
WasteBook.org	Worldwide	A website listing over 120 different waste exchange websites globally.	http://www.wastebook.org/matex.htm

Figure 2, below, displays a screen shot from the Construction Material Exchange website mentioned in Table 1 above. Multiple case studies involving the use of online platforms for encouraging circular economy practices can be found in a 2018 report from the C40 cities project[26].

[26] https://www.c40.org/researches/municipality-led-circular-economy

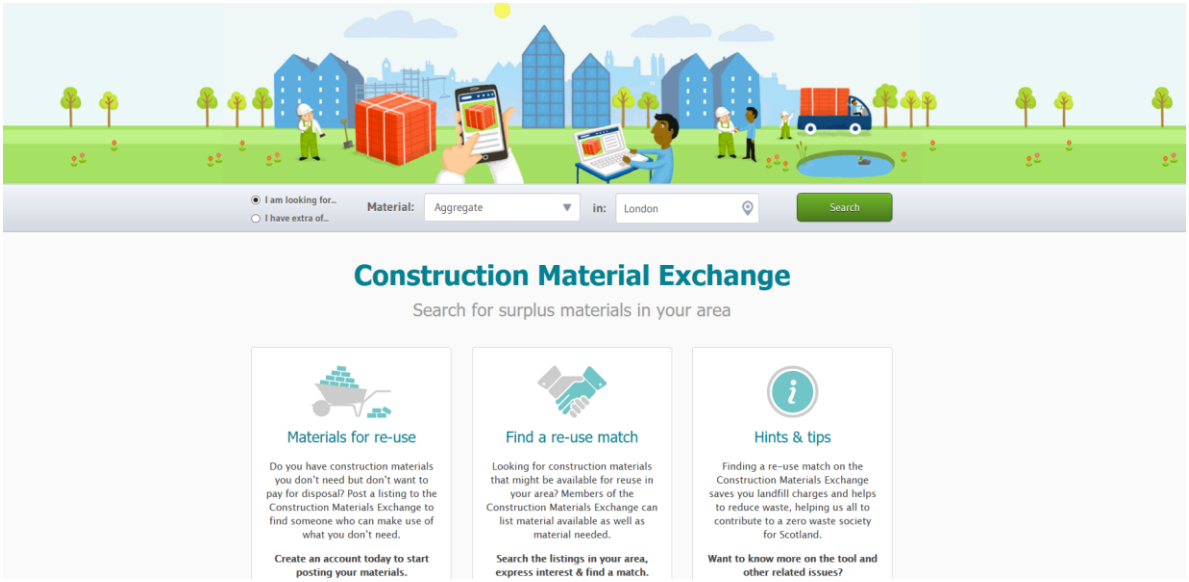

Figure 2: Screen shot from Construction Material Exchange website from Zero Waste Scotland.[27]

The primary functionality of the Material Exchange Platform is to enable users to search for and procure soon-to-be-released materials. All examples listed above rely on voluntary postings of materials/products by prospective suppliers. The utility of data identified in the data ecosystem mapping is limited in that any transaction will rely on prospective suppliers and procurers posting information and requirements. The only pre-existing reservoir of data on real (as opposed to estimated/projected) material release is planning data, though there are substantial challenges and limitations. Planning submissions relating to demolition works or major modifications may, in some planning systems, provide information as to the likely waste arisings from the works. This may then be matched with procurers for new projects. In some cases, such as under the new Circular Economy Statement planning requirements in London or the Demolitions Register in Helsinki/City of Vantaa, detailed data on expected material requirements by the project is provided, potentially creating a source of data on soon-to-be-released materials.

A more abstract indication of upcoming material release may be obtained through the use cases elaborated in previous sections. Identifying soon-to-be-demolished building stock segments and their material composition (see sections 4.1.3 and 4.1.4) can provide designers, procurers and planners with a better understanding of what materials are likely to be released in large quantities in the surrounding area of a planned development, informing design and procurement strategies that account for the expected high local availability of released products and materials. Additionally, the use cases of section 4.2 may be used by asset owners and managers to identify the types and quantities of materials that are likely to be required by their assets in future, which may guide proactive procurement from the MEP.

As well as matching sources of material release with sinks of material requirements, a further functionality of the MEP could be comparability

[27] http://cme.resourceefficientscotland.com/

between listings in terms of whole life carbon, financial value, waste to landfill and so on. Data on carbon and other environmental impacts is, in some cases, fairly easy to achieve using existing methodologies such as LCA.

4.5.2. **Circularity Atlas**

The aim of the Circularity Atlas (task 8.4) is to serve as a tool for policy-makers, industry, commercial interests and the public to visualise the material stocks and flows of the built environment, with particular regard to circularity. The intention is that this will facilitate and encourage circular decision-making.

The Atlas will comprise a Space Monitoring Service assembled from remote sensing data, into which various layers and analyses will be integrated for visualisation of relevant information. Firstly, the basic infrastructure of the Circularity Atlas, onto which it is presumed that relevant information will be overlaid to form an interactive Geographic Information System (GIS) visualisation, will require remotely-sensed data and land-use classifications data – this can be obtained from the Copernicus Land Monitoring Service, though in some cases there are additional land-use layers of relevance that may be added.

In terms of data to be integrated, much of that identified in the city/region data ecosystem mapping may be considered relevant and useful to visualise in and of itself. Further, some of the use cases elaborated thus far for WPs 4, 5 and 6 may be visualised with relative simplicity within the Circularity Atlas infrastructure. In many cases there will be raw (i.e. non-manipulated or combined) data that can be directly integrated into the Atlas and that will be illustrative in its own right (see section *'Integrated data: single datasets'* below), whereas in other cases the more complex results of modelling (as carried out as part of other WP workstreams) may also be integrated (see section *'Integrated data: use case outputs*).

Integrated data may be displayed for the whole region, per borough or per other delineated sub-regional area (e.g. Lower-layer Super Output Areas in London, a geographic unit with rough average area of 0.5km^2). The main prerequisite for integrating data into the Atlas is that it is geolocated to at least the level of the city/region; datasets with greater spatial granularity (i.e. borough-level, neighbourhood-level, postcode, coordinates, etc.) will allow more precise visualisation of material stocks, flows and related information.

Additionally, time series data (whether in the form of historical data or future projections) may be presented as an interactive map to visualise trends in the data across time.

4.5.2.1. *Integrated data: single datasets*

Single datasets that may useful or interesting to integrate into the circularity atlas include:

- Land-use classifications (as relevant, and that are not covered by the Copernicus Land Monitoring Service)

- Building stock figures – number of buildings, split by building stock segment
- Built area/volume, split by building stock segment
- Location and type of infrastructure
- Number of vacant buildings, split by building use class
- Construction material sales (expressed in volume, mass and/or value)
- Number of new completes, modifications and demolitions, split by building stock segment
- Waste arisings and flow data for CDEW, split by route (recycling, incineration, landfill; recycling may be subdivided by backfilling and reprocessing into manufacture; all may be subdivided into whether dealt with domestically or exported)
- Locations of waste facilities
- Waste facility returns data for CDEW, split by materials class and origin of waste
- Population growth trends and projections
- Future housing need forecasts
- Construction output; historic, current and forecast
- Major planned projects, locations and information
- Contextual factors influencing the built environment and its circularity, e.g. greenspace, cultural assets, local property market conditions

4.5.2.2. *Integrated data: use case outputs*

Useful insights may be achieved when data resulting from combinations and analyses of data as described in the use cases, such as:

- Volume/mass of urban material stocks, split by material and building/infrastructure stock segment (see section 4.1.1)
- Projected volume/mass of material release available for urban mining, split by material (see 4.1.3) may be visualised at a range of granularities where the data allows (e.g. by year, by decade)
- Projected material requirements for building stock (see section 4.1.7)
- Obsolescence rates, current and projected, split by building stock segment (see section 4.2.1)
- Transformation potential of current stock, split by building stock segment (see section 4.2.2)
- Area-level LCA and LCC comparisons of different rates and combinations of urban mining, building transformation and building abandonment (see sections 4.1.6 and 4.2.3)
- Material Flow Analysis visualisation
    - Dynamic spatial-temporal visualisation for material stocks and flows across sub-city areas and through time

- The effects of policies and changes in consumption patterns on material and waste flows may be modelled and visualised

4.5.3. **Circularity Dashboard**

The principal aim of the Circularity Dashboard is to display a variety of Circularity Indicators through which the performance of regions, cities, and sub-city areas may be visualised, compared and benchmarked. The exact circularity indicators are yet to be developed as part of CIRCuIT task 3.2, however they are likely to employ elements of the use cases elaborated in previous sections. For example, an ‘Urban Mining Index’ may display averages and breakdowns of historical, current and projected material release, and the rate at which it is reused and recycled; a ‘Lifespan Index’ may serve to indicate the projected lifespan of current built stock; indices may also be developed to display rate of obsolescence, and city circular potential (i.e. the potential rate of material reuse/recycling and building transformation).

4.6. General use cases

In this section, brief overviews are given of a range of tools and methodologies that require or would benefit from built environment data.

4.6.1. Material passports

“Imagine knowing how much a building was worth – every brick, beam, window, door and curtain wall – and which parts of it could be reused or recycled. With such detailed knowledge, the building would become more than just a here-and-now balance sheet asset. It would create a bank of components that had a potential future life and a known value beyond worthless demolition spoil.”[28]

The materials passport concept involves creating a digital document with a breakdown of the materials within a product and tracing each material over the product’s lifecycle. For buildings, it would be a very detailed inventory of building components, including specific component materials and characteristics. Some of the proposed characteristics include: physical properties such as dimensions, chemical properties such as lifecycle environmental assessment, biological properties such as decomposability, and material health such as impact on indoor air quality. This enables more efficient maintenance and end of life activities as it easier to identify and reallocate/repurpose resources. As more buildings adapt this approach, it creates a secondary market for building materials and adds economic value to otherwise discarded/demolished products. Overall this concept should also encourage manufacturers to improve their materials and products to facilitate secondary use (extending the product lifecycle – designing for deconstruction). For the materials passport be useful and comparable in different countries/regions, reliable and standardised information is critical. Standardisation is also helpful for producers as they would only need to supply the data in one format[29].

A current example of materials passports being used currently is the Madaster Foundation, a material passport platform in the Netherlands aggregating building data to provide information on materials and products that will be available in the future[30].

Within CIRCuIT, the materials passports concept could be relevant for: urban mining inventory and business models (WP4); the business case of building transformation (WP5); documenting the materials used for demonstrators (WP6); best practice examples (WP7); materials exchange (WP8).

4.6.2. Pre-demolition audits

Prior to the refurbishment or demolition of a building, it can be useful to survey the building’s site so that data on the volume, weight, type and condition of its structural components and internal fixtures and fittings can be collected and determined through further analysis. For the audit, surveyors

[28] https://www.architectsjournal.co.uk/news/material-passports-finding-value-in-rubble/10043989.article
[29] https://www.bamb2020.eu/wp-content/uploads/2019/02/BAMB_MaterialsPassports_BestPractice.pdf
[30] https://madasterfoundation.com/

will visit a building prior to any works taking place in order to capture dimensional measurements, photos and material descriptions of the building, its rooms and internal fixtures and features (e.g. windows, doors, staircases etc.). This data is then reviewed against (and combined with) existing building data such as floor plans to ensure greater accuracy of the data. The data is then used to produce a pre-demolition audit report that provides data to stakeholders on Key Demolition Products (KDPs) that are suitable for reuse and recycling. Reports can also make recommendations on:

- uses for structural components, and internal fixtures and fittings;
- suitable waste management contractors who can help in processing materials; and,
- relevant policies and regulations relating to the reuse and recycling of materials from a building demolition[31,32].

Stakeholders involved in the refurbishment or demolition can then refer to this data to better plan how certain structural components and internal fixtures and fittings can be removed during a refurbishment or demolition in order to maximise the value of recovered materials or avoid disposal costs through preventing unnecessary waste[33]. A typical output report section on concrete for an anonymised building is shown in Figure 3 below:

Concrete

Product description

Concrete is the major Key Demolition Product (almost 70% by weight) originating from the concrete frames, floors and stairs. The information provided gave limited details of the construction and some parts of the buildings were inaccessible so these figures are based on estimates from plans and visual assessment.

Location	Volume (m^3)	Weight (Tonnes)
Floor	9954.0	23889.5
Roof	1228.0	2947.2
Staircase	159.2	382.1
External wall	967.4	2321.7
Columns	526.0	1262.4
Walkway	10.3	24.7
Internal walls	89.1	213.8
Total	12934.0	31041.5

Table 3: Sources of concrete

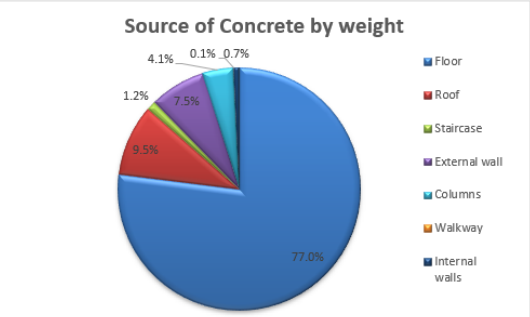

Figure 2: Sources of concrete

Figure 3: Breakdown of concrete volumes and weights in the components of an anonymised building

[31] https://www.smartwaste.co.uk/_predemolition-and-prerefurbishment-audits
[32] https://www.bregroup.com/buzz/pre-demolition-and-pre-refurbishment-audits/
[33] https://www.europeandemolition.org/industry/projects/pre-demolition-audit

Pre-demolition audits are relevant to the circular economy because they allow for systematic identification of building components and internal fixtures and fittings that can be reused or recycled in multiple applications to avoid linear disposal routes in line with the aims of the circular economy.[34]

The following specific objectives of WP4 link with the aims of pre-demolition audits:

- 'To develop a shared framework and methodology for Pre-Demolition-Audits, considering regional specifics, reuse and recycling';
- 'To determine the technical and economic feasibility of selective demolition techniques to preserve building elements and materials';
- 'To expand the evidence base on the reuse and recycling of building elements and materials for new applications in construction through the 12 demonstrations.';
- 'To provide data on materials for reuse for the Materials Exchange Portal and the City Circularity Atlas'; and,
- 'To determine the economic and environmental impact of the demolition, reuse preparation and recycling processes'.

The following specific objectives of other CIRCuIT WPs link with the aims of pre-demolition audits:

- WP5 - To apply, adapt and further develop evidence-based systematic methodology to identify obsolete and transformable buildings and neighbourhoods, and to use these methods to select specific demonstration cases.
- WP7 - To explore how embedded values of building materials e.g. energy and cultural values can be included in the assessment of a construction project and be a helpful tool in the dialogues with developers.
- WP7 - To demonstrate how to implement the EU guideline for pre-demolition audits in cities' demolition permits to promote high-value reuse and recycling.
- WP8 - a Materials Exchange Portal which will be based on the database outlined in WP3 and WP4. Here, materials "released" during demolition can be found by contractors.

More information on Pre-demolition audits can be found in the following documents and links:

- https://www.europeandemolition.org/industry/projects/pre-demolition-audit
- https://www.bre.co.uk/page.jsp?id=2132
- Guidelines for the waste audits before demolition and renovation works of buildings, EU Construction and Demolition Waste Management, European Commission report, May 2018

[34] https://www.ellenmacarthurfoundation.org/circular-economy/concept

4.6.3. **Circular Building Assessment**

Construction and refurbishment projects require many decisions regarding the building configuration and choice of building products and components. In order to support decision-making processes in an effective way, the performance and added value of design options for the user(s) and society should be carefully considered before making a selection.[35]

Circular Building Assessment (CBA) is a methodology that was developed as part of the Buildings as Material Banks (BAMB) PROJECT under the Horizon 2020 research and innovation programme. It has been developed to help evaluate product and material resource flows during the lifetime of a built asset and beyond. The methodology aims to quantify and compare building design approaches and compare differences between 'business as usual' versus circular building scenarios which include:

- reusing from the previous built environment;
- designing for future reuse via reversible building design; and,
- the potential to transform, highlighting the corresponding environmental and economic net benefits.[36]

The BAMB project led to the creation of a CBA software platform prototype, (see Figures 4 and 5 below) using Building information Modelling (BIM) to extract and combine building and product data from model export files, materials passports, building product data and supported data to create circular building scenarios for comparison as explained above.

[35] http://www.bambcba.eu/Home/About
[36] https://www.bregroup.com/buzz/circular-building-assessment-prototype/

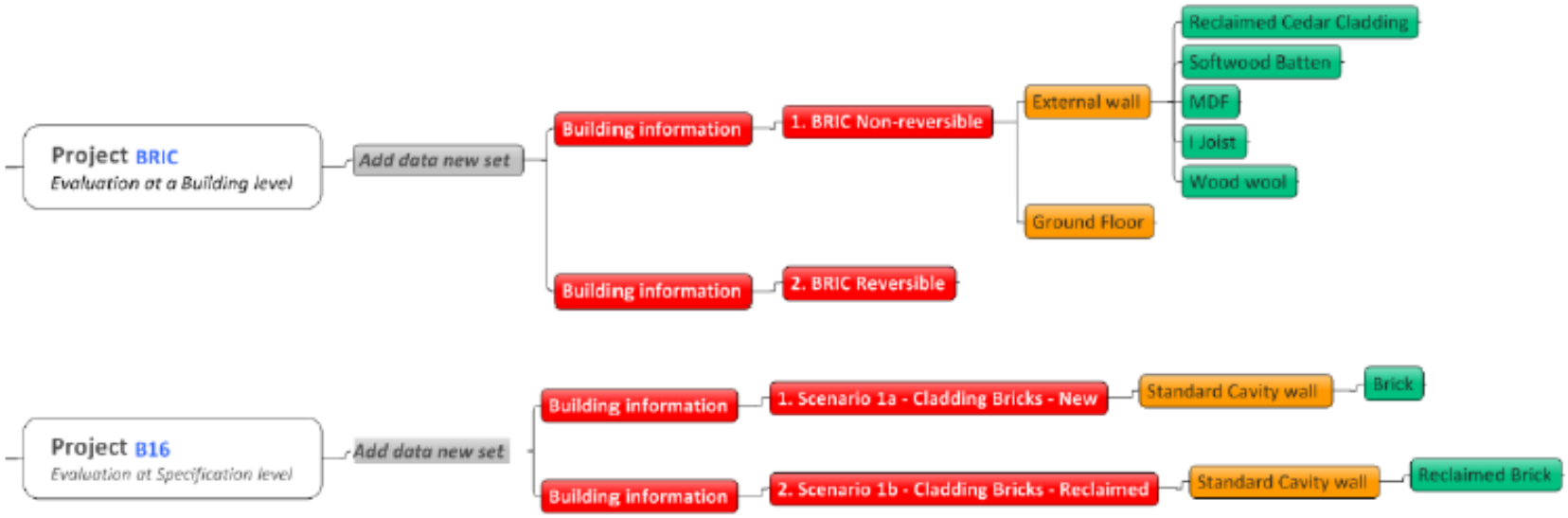

Figure 4: Scope of a CBA assessment

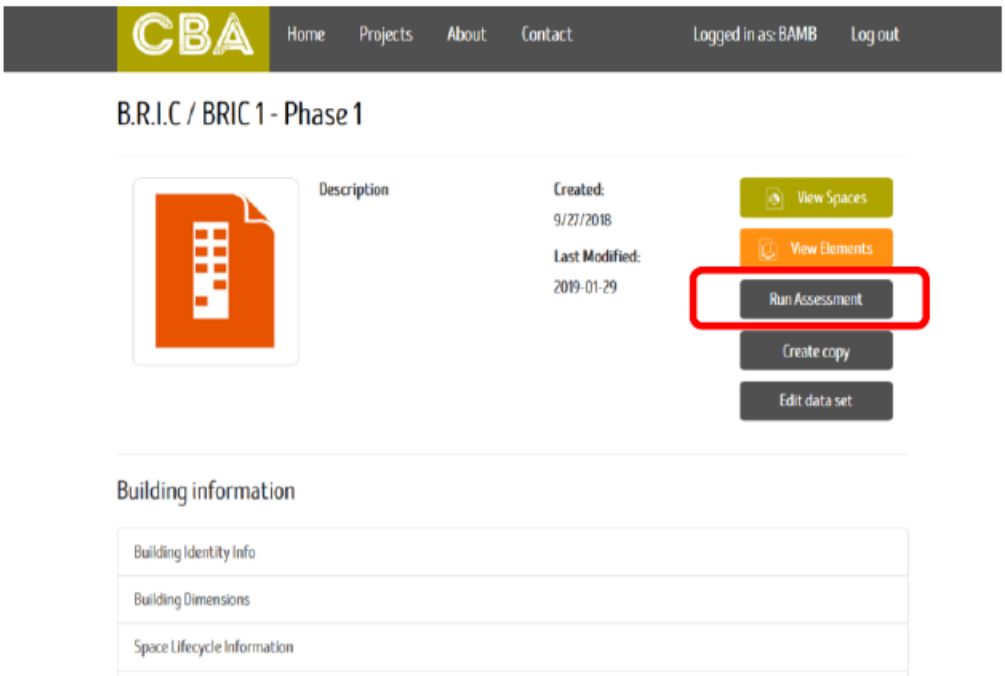

Figure 5: Webpage from of CBA prototype tool

A CBA can use the following data for analysis:

- Building Gross Internal floor area;
- Design life of the building;
- COBIE.xml files;
- Floor plans, sections and elevations;
- Construction specification of building elements & Global Warming Potential factor for various materials installed;
- Quantity of different materials present in various building elements;
- Element Cost information; and,
- Frequency or time intervals of maintenance, repair and replacement.

A CBA involves a multiple life cycle approach in which aspects, such as environmental impacts, financial costs, health consequences and social value are modelled to allow for systematic review of impacts of decisions taken on built assets by clients, designers and their advisors.

The following specific objectives of WP's link with the aims of CBA:

- WP4 – 'To determine the economic and environmental impact of the demolition, reuse preparation and recycling processes';
- WP5 – 'To assess the outcomes of the interventions in terms of environmental and economic impacts and other implications, such as social/cultural impacts –at the building level and the building stock level – in order to inform policy- and decision-making', and,
- WP6 – Within task 6.2, an objective is for 'Impact Assessment of building systems, demonstrator, and scenario impact and viability will be carried out

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 821201

via established methods (such as LCA and LCC, and TCO or ROI)…This should enable city stakeholders to shift towards life cycle assessments of construction projects'

More information on Circular Building Assessment can be found in the following documents and links:

- https://www.bregroup.com/buzz/circular-building-assessment-prototype/
- User guide for Circular Building Assessment (CBA) Web Platform PDF - http://www.bambcba.eu/Home/Downloads
- https://vlaanderen-circulair.be/reburg3/circular-building-assessment.html

4.6.4. **Extended Producer Responsibility**

EPR means extending manufacturers', importers', and sellers' responsibility to the post-consumer (end of life) stage of their products. It is a key instrument for EU resource efficiency and raw materials strategies. The aim is to incentivise producers to consider and account for whole lifecycle environmental impacts, especially during the product design stage. The outcome is reduced landfilling, increased reuse and recycling and, in the longer term, behaviour change amongst all stakeholders. Existing EPR schemes take a variety of forms including product take back and deposit refund arrangements, with producers paying some or all of the costs of collection and treatment of post-consumer waste. They can be mandatory or voluntary. Current EU laws for producer responsibility cover packaging, electrical and electronic equipment, batteries and end of life vehicles. Whilst EPR individually targets producers, collective schemes have emerged in practice to collect and treat the product at end of life and manage data acquisition and reporting for groups of individual companies. These groups also get involved with communication campaigns and operational interventions. Despite progress with these schemes across the EU, there is a significant lack of transparent, comparable and accessible technical and economic data. To operate effectively, schemes need to be based on reliable data on the quantity of product placed on the market, discarded at end of life, collected, recycled, exported or otherwise treated, and the associated fees and costs.[37]

EU 2018 Circular Economy legislation included strengthening EPR schemes such as ensuring that producers meet all end of life costs and incentivise waste prevention and recyclability in their fee structures.[38] It also requires mandatory EPR schemes for packaging by 2024 which is relevant as building and construction is the second highest application for plastics after packaging (piping, cladding, insulation, windows, etc.).[39]

Examples include:

- Vlakglas Recycling Nederland - voluntary scheme for flat glass waste collection and recycling in Netherlands[40]

[37] https://ec.europa.eu/environment/waste/pdf/target_review/Guidance%20on%20EPR%20-%20Final%20Report.pdf
[38] https://www.europarl.europa.eu/RegData/etudes/BRIE/2018/625108/EPRS_BRI(2018)625108_EN.pdf
[39] https://www.plasticseurope.org/en/about-plastics/building-construction
[40] https://www.vlakglasrecycling.nl/

- Eco-Mobilier – regulatory obligations for furniture manufacturers, importers and distributors in France[41]

This instrument could be relevant for: facilitating recovery options and data in urban mining (WP4); extending product lifecycles through recovery and reuse or improved product design (WP5); incentivising improved product design to minimize environmental impact such as design for disassembly, however there is no strong evidence directly linking EPR to eco-design (WP6); policy/regulatory approaches of which there are multiple examples in practice (WP7); information dissemination through producer responsibility organizations that are already known to be involved with communication campaigns (WP9).

[41] https://www.eco-mobilier.fr/wp-content/uploads/2018/09/note_d_info_fabricants_europeens_internationnaux_uk_2018_v2.pdf

5. Latest innovation in facilitating material-based mass scanning of existing building stock

To build effective circular policy and identify key opportunities for circular commercial ventures as related to the construction sector and its constituent material stocks and flows requires access to and analysis of high-quality data. The data ecosystem mapping of the four CIRCuIT city clusters identified an extensive body of datasets, representing a multitude of data capture and analysis techniques, permitting the formulation of a range of use cases. However, it became evident that, at an aggregate level, the data ecosystems suffer from issues with completeness, granularity, accessibility, up-to-dateness, standardisation, and accuracy (see section 3), limiting the number and quality of available use cases.

Concurrently, innovative techniques with potential to improve data capture and utilisation were identified through research and discussions with key industry and academic stakeholders. In particular, and as a key defined output of Deliverable 3.1, multiple innovations were identified facilitating the characterisation and quantification of material stocks in the existing building stock, comprising analytical techniques, data capture technologies, data capture methodologies, and wider contextual enablers of data capture and utilisation. A selection of these 'mass scanning' facilitators are listed and briefly described below; a fuller list, including evaluations of advantages, disadvantages and applicability will be included in the deliverable report D3.2.

Note that some of the innovations listed are not novel, however their application in a certain manner or at a large scale could be classed as innovative.

- *Material Flow Analysis (MFA) and related techniques.* In recent years, there has been an expansion of interest and research from academia and, increasingly, industry, in performing analyses of existing data to characterise and quantify materials embodied within built stocks, and to predict likely material outflows upon demolition. There are various methodologies which make use of a range of different data types; many of the methodologies described in section 4.1.1 come under the banner of MFA and similar. For reviews see (Augiseau & Barles 2017). While MFA and related stock-taking methodologies are not novel, their application as a driver of urban decision-making is underutilised.
- *Building automated survey technologies.* Increasingly, automated technologies are available that allow precise and accurate surveys of buildings and infrastructure. Types of available sensing technology include 2-dimensional LIDAR (Light Detection and Ranging), 3-dimensional LIDAR, depth cameras, electro-optical cameras, infrared cameras, RADAR (radio detection and ranging), as well as technologies to measure additional specific physical attributes such as moisture and temperature. These technologies may be guided manually by humans to survey building interiors, or they may be affixed to drones or other vehicles to allow fuller building surveying. The more widespread use of these technologies increases the ease of characterising the building stock, and also increases

the volume of digital data which may be collated and analysed. In some cases, commercial applications are analysing data with machine learning algorithms to ascertain construction type and products and materials present within the asset.

- *Remote sensing.* Remote sensing technologies involve the use of satellites or high-flying aircraft to gather imagery, LiDAR data, or other data indicating the layout, geometry and typological characteristics of building stock. This data may be analysed using photogrammetry and machine learning/computer vision techniques to quantify numbers of different building typologies, as well as to analyse changes through time through change detection analysis.
- *Photogrammetry.* As applied to the built environment, photogrammetry involves the inference of obtaining useful information about built stock (e.g. dimensions) from image data. With the large amount of image data becoming available through platforms such as Google Street View or social media platforms, a large potential reservoir of urban data is becoming available for analysis.
- *Machine learning.* In recent years, a range of techniques have emerged which make use of machine learning and computer vision algorithms to perform photogrammetry (see above) and classification of building attributes and typologies. When applied to area-level data such as street-level imagery, remotely sensed data or land use and mapping data, machine learning methods may be used for the classification, dimension measurement, and quantification of buildings and infrastructure, from which material quantities may be derived. Additionally, such approaches may be used to quantify changes in built volume or area through time, indicating material requirements and release.
- *Connectivity-of-things.* The development of digitisation, interconnectivity and data exchange capabilities within the physical components of built environments can yield improved traceability and an understanding of the position and condition of these components (Wilson 2020, personal communication). Through technologies such as sensors and tracking methods (e.g. RFID tags and QR codes, as well as more novel technologies such as DNA-of-things[42]), geolocated data on the stocks of *in situ* materials and products may be obtained. These concepts are a core component of the concepts of Industry 4.0, which the construction industry is increasingly working towards (Wilson 2020; Maskuriy et al 2019).
- *Crowdsourced data and citizen science.* Increasingly, insights are becoming available to researchers through the analysis of citizen-generated data shared with platforms, whether purpose-built for built stock quantification or otherwise. For instance, projects and platforms such as World Urban Database and Access Portal Tools (WUDAPT)[43] and Colouring London[44] rely on the gathering and provision of data by the public to build large-scale datasets on the built environment and its constituent materials.
- *Material passports/inventories.* The compilation of material inventories of buildings and infrastructure presents one of the routes to achieving granular

[42] Koch et al (2020). A DNA-of-things storage architecture to create materials with embedded memory. *Nature Biotechnology* **38**:39-43.
[43] http://www.wudapt.org/;
[44] https://colouringlondon.org/

and accurate building- and asset-level data. Where this is achieved for the entirety of built stock, data may be aggregated to yield true material quantities for the purposes of mass scanning. See Heinrich & Lang (2019) and section 4.6.1.

- *Offsite modular construction.* The standardised dimensions and embodied materials of buildings and components constructed offsite means that it is relatively easier to calculate the materials within such structures.
- *Open data access and centralised data.* In a general sense, the centralisation of data from multiple sources will allow improved visualisation of the overall data ecosystem, as well as a significantly increased ease of analysis for data-driven decision-making. There is currently a major drive towards open data, largely from governments and local authorities. The continuation of this trend and its adoption, where feasible, by industry would allow significantly improved utilisation of data.
- *Data economy.* A significant barrier to improved data is the areas where it is absent or held privately. In particular, and on a related note to the previous point of increasing open data licensing, the increasing collection and open provision of data from stakeholders involved in the handling, surveying, installation and removal of materials from built stock could significantly improve understanding of material stocks and flows. The concept of a ‘data economy’ comprises the idea that data, which may be useful to a range of stakeholder other than those who collect the data, for a range of reasons, has a value. This value means it may be sold to interested parties, and may ultimately incentivise the collection of a higher volume and quality of useful data.
- *Distributed ledger technology.* Distributed ledger technology such as blockchain is increasingly seen as a facilitator of the traceability of materials in the built environment, since it allows an uncorruptible chain of information on the movements of materials between actors (Wilson 2020, personal communications). This ‘golden thread’ of material or product information means that critical information on built assets is readily compiled into a digital record and preserved (Watson, Kassem & Li 2019). Hypothetically, such data may be anonymised and explored when held in distributed ledgers.

6. Conclusions and final remarks

This report described the methodology and initial findings of a data ecosystem mapping of the material stocks and flows of the built environment in the four CIRCuIT city clusters of London, Helsinki/Vantaa, Copenhagen, and Hamburg.

The mapping found that data capture on material value chains and their influencing factors is often fragmented, inconsistent and, on the whole, does not allow a full, accurate picture to be established of the stocks and flows of materials in cities. Data is collected for numerous reasons and according to numerous methodologies, and is presented in a wide range of units, formats, at varying levels of granularity, and with varying levels of accessibility. Sources of data range from crowdsourced data to that gathered as part of an organisations operations and held on private databases to governmental data and statistics. Often, there is little transparency in terms of the information on data collection techniques and statistical techniques used to process raw data into datasets or analyses. However, productive uses are achievable using the available data, as exemplified in the use cases elaborated in section 4. Notwithstanding, better integration and consistency of data capture at the city-level, presented in centralised and openly accessible databases, with any data gaps filled, will significantly improve understanding and decision-making leading to more circular cities in terms of built environment materials.

The mapping and related research into methodologies for utilisation of the data also resulted in a range of suggested use cases that may be utilised within other CIRCuIT workstreams. The ease and technical feasibility of carrying out these use cases is yet to be fully explored, and it is likely that other data sources and methodologies exist which have not yet been identified.

Next steps within the Task 3.1 workstream include making a full set of recommendations for improving the capture and utilisation of data relating to material stocks and flows of urban built environments; these will be presented in deliverable D3.2. Additionally, findings will be incorporated and built upon in the development of Circularity Indicators as part of Task 3.2. Finally, while this report presents the initial findings of the data mapping activity, and is a useful starting point to guide other CIRCuIT workstreams, it is expected that new data and ways of exploiting that data will present themselves over the course of the project. In an iterative process, these will continue to be integrated into updated findings of WP3, and presented to the wider project consortium as necessary for incorporation into other work packages.

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Appendix 1: City Data Map template

Data subject	Example of parameters	Potential sources
BUILDING DATA		
Current split of building types (% land use, number of units, valuation)	By sector (housing, commercial, industry)	Studies (academic, Government), planning data
	By age groupings	
	By typologies e.g. apartment housing, concrete frame + brick and block infill	
Use of buildings	Renovation patterns	Planning data, business register data
	Vacancy rates	
	By occupation	
Levels of demolition	By sector (housing, commercial, industry)	Studies (academic, Government), planning data
	By age groupings	
	By typologies e.g. apartment housing, concrete frame + brick and block infill	
	Good examples of selective/ high & reuse demolition e.g. 3D demolition simulation, concrete recycling robot	
Future building requirements	By sector	Planning data
	By scale	
	Large infrastructure projects	
MATERIAL AND PRODUCT DATA		
New construction products and material consumption	Building level e.g. housing, commercial, infrastructure	Studies (academic, industrial, Government)
	Sector level e.g. plasterboard, structural timber, windows	Manufacturers sales data and trade bodies
REUSE, RECYCLING AND OTHER WASTE DATA		
Construction/demolition/refurbish-ment waste benchmarks	Tonnes or m^3 waste relative to floor area or 100K euros	Waste statistics (Eurostat/National/Municipal) , industry data
	% material breakdown by volume of weight	
	Total tonnage produced	
	Typical recycling/ reuse/ energy recovery etc rates	
	Typical costs for waste management	
General data on construction, demolition and excavation waste – especially precise information as indicated in the 'benchmark' section is not available	Amounts (tonnes/year)	Waste stats (Eurostat/National/Municipal), industry data
	Material breakdown (tonnes or %)	
	Levels of reuse, recycling, recovery etc..	
Current levels and trends for use of reclaimed (reused/secondhand) construction products (e.g. online platforms for reclaimed materials and usable building parts, salvo.co.uk Purkutorin.fi)	By product or material type	Surveys, trade bodies
	By sector e.g. housing	
	By company type e.g. third party urban mining, deconstruction companies, in house	
Current levels and trends for use of recycled products and materials	Recycled content of product groups	Studies (academic, industrial, Government)
e.g. RAL Quality Assurance for recycled construction materials	% Bulk materials e.g. recycled aggregates as % all aggregates	Studies (academic, industrial, Government), waste statistics, planning data

	Financial incentives (e.g. landfill tax)	Government
PROCESS, STANDARDS DATA		
Sustainability standards for buildings e.g. BREEAM	Relevant credits/ adaptation of approach, tools and standards used to assess whole life costs	Scheme providers, planning
Social value assessment	tools or standards to measure	Social return on investment calculation method
Health & well being assessment	tools or standards to measure, e.g. material passport	Methodology/ case studies
Economic assessment	Whole life costing analysis tools/standards	Standards/ Software/ Methodology/ case studies
Environmental assessment	tools or standards to measure, such as EPDS for construction products, LCA software for buildings	Standards/ Software/ Methodology/ case studies
Pre-demolition audits undertaken	A standard or evidence/case studies e.g. EU CDW Protocol	Studies (academic, industrial, Government)
POLICY DATA		
legal requirements that influence circularity	mandatory pre-demolition audits, Eco-design, extended producer responsibility, eco labelling etc	city/region or national policy
fiscal aspects that influence circularity	Green public procurement requirements/ weighting, tax / subsidies in place	city/region or national policy
direction of travel'	guidance, roadmaps, case studies, support for voluntary best practice	reports, websites, help lines, events
DATA STANDARDS		
Building information modelling related	number/% of built assets scanned/have a BIM	reports, standards/ authoring software, training courses available
Classification systems typically used	Building typologies, product groupings	city/region or national policy/usage
Circularity Indicators	Existing Key Performance Indicators in use/proposed	Circularity reports/ software/ consultancy
OTHER/ MISC		
Physical context	Land use mapping, transport, climate, green/blue infrastructure	GIS, local development plans, mapping portals
Economic context	Local economy stats, future trends of growth. Breakdown of industry by sector esp. focus on 'circular economy' related.	reports, websites, local enterprise targets and themes
Social context	health & well being stats, Social deprivation stats	reports, websites etc.
Environmental context	Energy, water, resources consumption, other waste flows, pollution	Mass flow analysis, urban metabolism, energy & water related reports/modelling software/ support/ targets etc..

Appendix 2: Data tables from city mapping exercise

Note: discrepancies between the data table formats and contents are due to recent updates which were intended to aid usability of the tables and which have in some cases not yet been fully adopted by all city clusters. However, the basic content is identical between data tables, and any extra details and patterns drawn out in analyses that is not highlighted in the tables, such as commentaries on accessibility, was clarified during one-to-one discussions and explorations of the data with the individuals from each city cluster responsible for data mapping.

COPY EACH CITY SPREADSHEET IN HERE


CIRCUIT

COPENHAGEN DATA SOURCES - BUILDING STOCK										
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**	**Format**	**Units**	**Smallest geography**	**Volume of data**	**Time range & frequency of data collection**	**Ongoing/ Inactive/ Not yet active**
BBR (Danish Building and Dwelling Register) - Property level	BBR is the Danish Building and Dwelling Register. BBR is the main register/database with information about all legal constructed buildings in Denmark. Information registered on property level in BBR can be: - Property identification number - Ownership relation - Property Update Date - Number of Buildings - Number of units (residential vs commercial) - Approximate floor area (heated and non-heated) - Total legal living space (heated) - Number of small buildings - Built Area	Udviklings- og Forenklingsstyrelsen (The Ministry of Taxation)	Property data: https://boligejer.dk/ https://www.ois.dk/ National data: https://datafordeler.dk/	Open on property level National data require payment	PDF or raw data	Multiple	Apartment	All buildings	Old; Everyday	Ongoing
BBR (Danish Building and Dwelling Register) - Building level	BBR is the Danish Building and Dwelling Register. BBR is the main register/database with information about all legal constructed buildings in Denmark. Information registered on individual building level in BBR can be: - Building identification number - Use of the building (e.g. single family-, terraced- or apartment house - Access conditions (to road or through house or garden) - Number of actual residential apartments - Number of single rooms - Year of Construction - Year of major renovations or extension - Construction conditions (only for buildings with reinforced concrete frame) - Exterior wall material - Roofing Material - Source of Materials - Total building area - Total living space - Total commercial area - Built area - Number of floors - Utilized area of attic - Total basement area - Heating installation - Building Update Date - preservation status - Demolition notification date - Demolition completed date	Udviklings- og Forenklingsstyrelsen (The Ministry of Taxation)	Property data: https://boligejer.dk/ https://www.ois.dk/ National data: https://datafordeler.dk/	Open on property level National data require payment	PDF or raw data	Multiple	Apartment	All buildings	Old; Everyday	Ongoing

BBR (Danish Building and Dwelling Register) - Unit level	BBR is the Danish Building and Dwelling Register. BBR is the main register/database with information about all legal constructed buildings in Denmark. Information registered on unit/apartment level in BBR can be - Floor number and side - Identification number for apartment - Use - Housing Type - Areas (legal living space/commercial space and total areal - Number of rooms - Removable walls - Number of toilets and showers - Kitchens - Energy supply	Udviklings- og Forenklingsstyrelsen (The Ministry of Taxation)	Property data: https://boligejer.dk/ https://www.ois.dk/ National data: https://datafordeler.dk/	Open on property level National data require payment	PDF or raw data	Multiple	Apartment	All buildings	Old; Everyday	Ongoing
SAVE - Architectural preservation values for buildings	Architectural-, Cultural History-, relation to surroundings-, Originality- and Condition assessment of the building	Slots- og Kulturstyrelsen (The Agency for Culture and Palaces)	https://www.kulturarv.dk/fbb/index.htm	Public	Webpage database		Building	A thrid of all buildings in Denmark	1987 - present	Ongoing
Building Energy Performance Certificates (Energy Label)	Energy calculation of the building based on an inspection of the building. - Outer wall areas - Roof areas - Windows areas - Floor areas - Window and door areas - U-values - Building systems	Energistyrelsen (The Danish Energy Agency)	Access to Energy report: https://sparenergi.dk/forbruger/vaerktoejer/find-dit-energimaerke www.boligejer.dk Access to Energy calculation: https://emoweb.dk/emodata/test/	Public	Energy report and energy calculation		Building	A thrid of all buildings in Denmark	Everyday - labels are deleted after 10 years	Ongoing
Price index for sales of property - Region	Database EJ14: Price index for sales of property (2006=100) by region, category of real property and unit - One-family houses - Owner-occupiued flats	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=EJ14&PLanguage=1	Public	Excel	Index 2006 (100%)	Region	Denmark	Monthly since 2006	Ongoing
Sales of property by region and by provins	Database EJEN77: Sales of real property by region and by provins, category of real property, key figures and type of transfer (quarter) - One-family houses - Residential properties with 2 or 3 flats - Residential properties with 4 flats and over - Residential and business properties - Business properties - Industrial properties and warehouses - Agricultural properties - Weekend cottages - Building sites (unbuilt area not agriculture) total - Owner-occupied flats	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=EJEN77&PLanguage=1	Public	Excel	Number, Average price, sales	Region	Denmark	1992 - present; Four times a year	Ongoing

Average floor area in new buildings	Database BYGV06: Average floor area in new-constructed dwellings by use - Farm Houses - Single family houses - Row houses - Apartments	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=BYGV06&PLanguage=1	Public	Excel	m2	Region	Denmark	1916 - present; Annual	Ongoing
DGNB certification	DGNB certification of new buildings and renovations - LCA - Energy calculation - Air quality - Daylight - LCC - Water use - Social relations - Acoustics	Building owner	https://www.dk-gbc.dk/	Private	DGBN raw data	Multiple	Building	Building	When a new certification is done	Ongoing
Building drawings	Digital building drawings archive	Danish Municipalities	www.weblager.dk https://public.filarkiv.dk/	Public	PDF		Building/building parts	Most of Denmark	Very old	Ongoing

HAMBURG DATA SOURCES - BUILDING STOCK

Title	Description	Source/ contact	URL	Accessibility	Format	Units	Smallest geography	Volume of data	Time range & frequency of data collection	Ongoing/ Inactive/ Not yet active
Building block map	Digital building block map based on the official real estate map (ALKIS). Changes are bundled as far as possible and introduced in the 4th quarter of each year. The changes are made available year by year in xls tables (LGV-SharePoint or SDP). In 2015, the classification was changed to gross building blocks; the old presentation in the form of net building blocks is frozen as of the beginning of 2014 and can be obtained separately if required.		https://metaver.de/trefferanzeige?docuuid=1EB1F56B-893E-495E-B930-2D86B284497B	Public			Neighbourhood		from 01/1999	Inactive
Report - Housing and Urban development	Report on the major Hamburg urban development projects and Senate opinion on the request of the citizenship of December 15, 2016: "We create modern Hamburg: housing, tenant protection, urban development - Continue successful urban development policy in the sense of a socially fair, liveable and affordable metropolis! : Housing construction and housing promotion continue at a high level in the longer term "Drucksache 21/7012		http://www.buergerschaft-hh.de/parldok/tcl/PDDocView.tcl?mode=get&lp=21&doknum=18216	Public			Neighbourhood		03.09.2019	Inactive
Number of dwellings and net additional dwellings	Apartments by type of building and type of use	Source: Statistics Office North	https://www.hamburg.de/wohnungsbestand-in-hamburg/	Public			City wide		2011/12	Inactive
Dwellings by Property Build Period	Map of buildings in Hamburg, coloured according to their year of construction or the first officially approved structural change.		http://hannes.enjoys.it/geo/odd2014/baujahr.html	Public			Point location		2014	Inactive

Dwellings by Property Build Period	Statistic: Buildings with living space and residential buildings by year of construction	Source: Statistics Office North	https://ergebnisse.zensus2011.de/#StaticContent:02,GWZ_1_1_1,m,graphic	Public			City wide		2011	Inactive
Dwelling stock	1) Statistics on living in Hamburg Household sizes Rental costs Social housing rents new letting rents housing allowance Residential construction in Hamburg Building completions 2018 Residential portfolio Foreclosures 2) Map of owned properties housing associations		https://www.mieterverein-hamburg.de/de/aktuelles/statistiken-wohnen-hamburg/ https://wohnungsbaugenossenschaften-hh.de/hier-sind-wir-zuhaus/	Varies			1) City wide 2) Point location		1) 2) issued in 2019	
Registered social landlord housing stock	On this map you can see at which locations housing construction with social support has been possible since 2011. For reasons of data protection, the positions given are approximate. If you click on a symbol, a window opens with further information.		https://www.hamburg.de/bsw/karte-wohnungsbaufoerderung/	Open			Point location		jan-17	Inactive
Housing data per district	Statistical data on housing in Hamburg districts on 31.12.2014 of the North Statistics Office.These are final results of the housing update based on the building and housing census 2011. They include housing in residential and non-residential buildings as well as dormitories. The average apartment size and the average living space per inhabitant are given in m².		https://metaver.de/trefferanzeige?docuuid=3D284DF4-B411-47A8-A421-9D34EA1D6CEA	Open						
Number of vacant dwellings	Statista Research Department, Vacancy rate of apartments in Hamburg from 2001 to 2017		https://de.statista.com/statistik/daten/studie/252750/umfrage/leerstandsquote-von-wohnungen-in-hamburg/	Public			City wide		2001-2018	Inactive
Number of upper floors	The buildings in Hamburg, colored according to the number of their (above ground) floors.		http://hannes.enjoys.it/geo/odd2014/geschosse.html	Public			Point location		2014	Inactive
Commercial and Industrial Floorspace	Table of the Chamber of Commerce (source: Federal Statistical Office) showing Graphs of completion of commercial and non-commercial buidlings from 1980-2018 in Hamburg.	Source: Statistics Office North	https://www.hk24.de/produktmarken/beratung-service/konjunktur-statistik/hamburger-wirtschaft-zahlen/produzierendes-gewerbe/3676944	Public			City wide		2018	Inactive
Building permits	building permits granted since 2011 (per district) at a glance	www.hamburg.de/wohnungsbau info@bue.hamburg.de	https://metaver.de/trefferanzeige?docuuid=548AE319-98B9-4E5B-B5C4-192DC8F4EF4D	Public			Borough		2011-2014	Inactive

Historical monument mapping	The monument mapping is part of the monument information system Hamburg. The mapped objects are linked to the factual data via the object number, so that selected information can be retrieved via the map. Current monuments are recorded.		https://metaver.de/trefferanzeige?docuuid=3B43E143-2C8B-43E8-8004-EE9EDA3EA563	Public			Point location		2012	Inactive
Completed construction projects	Overview of all completed apartments (per district) in 2013		https://metaver.de/trefferanzeige?docuuid=827E2FD3-C1E3-4BC6-B914-F22B5C5FB723	Public			Point location		2014	Inactive
Building plans with energetic specifications	Development plans (binding urban land-use plans, B plans) are legally binding plans, which include construction stage plans, partial development plans, implementation plans and, since 1962, the current development plans according to the Federal Building Act (BBauG) and, since 1986, according to the Building Code (BauGB). In a series of development plans drawn up over the last 20 years or so, the supply of heat for heating and hot water to the new buildings was specified. Usually the heat supply from a heating network (connection and use requirement) was determined. Differences are given above all by differently high quality requirements to the heat net. These are shown in different colours.		https://metaver.de/trefferanzeige?docuuid=AB1EB703-3917-4697-9A2B-AC6E49E9344B	Public			Borough		2018	Ongoing

District renovation projects	The City of Hamburg (Environment and Energy Authority) accompanies, supports and promotes energetic neighbourhood concepts that highlight measures to increase the overall energy efficiency in a neighbourhood and bring them to implementation maturity. The objectives are, among others, the advancement of energetic renovation measures of buildings, the development of renewable energy sources and waste heat sources, the achievement of cost saving effects through the participation of several actors and the encouragement of several building owners in a neighbourhood to jointly implement energetic measures. The KfW programme "Energetic urban renewal" promotes in-depth integrated neighbourhood concepts. In addition to the energetic aspects, all other relevant urban development, monument conservation, building culture, housing and social aspects are considered in these neighbourhood concepts. The aim is to carry out a detailed examination of technical and economic energy saving potentials in the neighbourhood in order to identify concrete measures for short-, medium- and long-term CO2 emission reduction on this basis. In addition to KfW's federal funds, the Environment and Energy Agency supports the development of neighbourhood concepts with state funds, provided that certain requirements are met. The map shows districts in Hamburg that are being implemented or have been implemented in the course of these programmes and provides information on the status of the project.		https://metaver.de/trefferanzeige?docuuid=24EC0F62-F7F0-4D0A-9A5B-B7500E8B5961	Public			Borough		apr-19	Ongoing
Brick areas and ensembles worth preserving in Hamburg	Hamburg's architectural heritage is characterised by its brick areas, especially those of the 1920s and 1930s. In order to develop ways of preserving the appearance of these areas - for example through special additional funding for a facing of bricks with state subsidies - the first step was to map the brick stock worth preserving. The following categories (levels, layers) are contained in the monument mapping: - Monument objects (symbolic): e.g. statues, fountains, monument complexes without clear extension - Boundary stones: historical boundary stones and boundary markings - architectural monuments: e.g. buildings, bridges, structural facilities - waters: e.g. harbour basins, canals, locks, ponds in parks and gardens - garden monuments: e.g. public parks and gardens, historical cemeteries - ensembles: consisting of at least two objects		https://metaver.de/trefferanzeige?docuuid=4FA654D8-C190-41B9-9A7B-2F1F5A3378EE	Public			Borough / Point location		data from 2012-2014 issued in 2018	Ongoing

HELSINKI DATA SOURCES - BUILDING STOCK

Title	Description	Source/ contact	URL	Accessibility	Format	Units	Smallest geography	Volume of data	Time range & frequency of data collection	Ongoing/ Inactive/ Not yet active
Regional Base Register (SePe)	Buildings: Basic building information (building code, addresses, floor area, purpose of use, number of storeys, year of construction, construction material, facilities, network connections, apartments etc.). Contains building projects and completed buildings, demolished buildings only partially. Area or point geometry Real estates: Basic real estate information (real estate code, area, type of real estate, registration date). Unseparated parcels. Mainly areal geometry City plans: Wireframe of city plans containing basic information on planning process (date of ratification and other stages), type of city plan (first plan, plan change, underground plan etc.). Contains ratified plans, proposed city plans and drafts for city plans. Mainly areal geometry City plan units: Information on use class, designated building rights (floor area), plot ratio, extension building rights, type of city plan unit. Mainly areal geometry Building land reserves in city plans (SeutuRAMAVA): Spatial dataset of ratified city plan units and their building land reserves. Contains information on designated building rights, already used building rights, building rights that were left for construction divided into residential/workplace/other construction, land ownership (classified in 40 categories). Mainly areal geometry	Helsinki Region Environmental Services Authority HSY	https://www.hsy.fi/en/experts/regional-data/geographic-information/Pages/SePe.aspx	Partly public, only for municipalities			Area and point location	Helsinki Metropolitan Area (Helsinki, Espoo, Vantaa, Kauniainen)	Every 2 weeks	Ongoing
SeutuCD	SeutuCD is an annually published, extensive collection of geographic information, which compiles the most essential register, map and data for planning related to the planning of the Helsinki Metropolitan Area. The material package is intended for the use of designers and researchers working for the municipalities in the Helsinki Metropolitan Area, HSY and HSL, as well as for background information of consultation work ordered by these parties. SeutuCD includes real estate and municipal register data: buildings, city plans, population and real estates. It includes also base maps and background data for planning such as future plans for public transportation, fixed routes and stops for public transportation, population projection and building land reservers.	Helsinki Region Environmental Services Authority HSY	https://www.hsy.fi/en/experts/regional-data/geographic-information/Pages/SeutuCD.aspx	Partly public, only for municipalities			Area and point location	Helsinki Metropolitan Area (Helsinki, Espoo, Vantaa, Kauniainen)	annual	Ongoing

YKR yhdyskuntarakenteen seurantajärjestelmä Built environment information system	Number and floor area of buildings, split according to purposed use; Number and floor area of residential flats; Holiday apartments, split according to build year; Business sites for sales / market (2010 forward).	Finnish Environment Institute	https://www.ymparisto.fi/fi-FI/Elinymparisto_ja_kaavoitus/Yhdyskuntarakenne/Tietoa_yhdyskuntarakenteesta/Yhdyskuntarakenteen_seurannan_aineistot	Public, needs a permit			Borough	National	Annual	Ongoing
Liiteri	City plan data. Planning frameworks and policies that set out future development for boroughs as a whole, as well as at a more granular level for neighbourhoods.	Finnish Environment Institute	https://liiteri.ymparisto.fi/	Public, needs a permit			Borough / point location	National	Present	Ongoing
Building information, Building and dwelling register	Real estate and building code Addresses of the building Location coordinates Municipal sub-area Name and address of the owner Type of owner (for example person, housing corporation, municipality or the state) Planning situation when building permit was granted (for example master plan, building plan or no plan) Site ownership status (owner-occupied or rented) Size (for example gross floor area and number of storeys) Facilities (for example lift, sauna or swimming pool) Year of construction Purpose of use (for example detached house, terraced house, block of flats, summer cottage or school) Network connections (incl. sewerage, water and electricity) Building permits granted Contact details of those granted building permits Construction and facade material (for example wood, concrete or glass) Method of heating (for example oil, electric or wood heating) Fuel (for example oil, electricity, wood or geothermal energy) Number of apartments Residents in the buildingApartment code Floor area Tenure status (owner-occupied or rented) Occupancy status (for example inhabited or uninhabited) Number of rooms and type of kitchen Facilities (for example sauna or balcony) Habitants of the apartment	Population Register Centre	https://vrk.fi/en/building-information	Puclic, chargeable			Point location	national		Ongoing
Buildings and free-time residences	Number of buildings by intended use and year of construction and heating fuel	Statistics Finland	http://pxnet2.stat.fi/PXWeb/pxweb/fi/StatFin/StatFin__asu__rakke/?tablelist=true	Open data			Borough	national	Annual, latest year in web	Ongoing
Building and dwelling production	Data of building permits, building projects strated and building projects finished (number of building permits, building area and volume, number and area of dwellings) split according to purposed use	Statistics Finland	http://pxnet2.stat.fi/PXWeb/pxweb/fi/StatFin/StatFin__rak__ras/statfin_ras_pxt_118r.px/	Open data			National, municipal data chargeable	national	Annual, even monthly	Ongoing

Building costs, building cost index	The building cost index describes relative changes in the building costs of building works and buildings of essentially identical structures by monitoring developments in the prices of the basic inputs used in their building. Index describes professional newbuilding or renovation building performed by building contractors.	Statistics Finland	http://pxnet2.stat.fi/PXWeb/pxweb/fi/StatFin/StatFin__hin__rki__kk/?tablelist=true	Open data			National	national	1951 - present; Monthly	Ongoing
Renovation building	Describes the renovation activity of building construction annually. Contains information from the profit and loss accounts of medium-size and large construction companies on their construction turnover divided into new building and renovation building. The renovation building of the companies is further divided into renovation of dwellings and renovation of other buildings. Classification by size category, whole country, major regions, age of building.	Statistics Finland		Open data			National	national	1996 - present; Annual	Ongoing
Combined Detailed Plans of Cities	A combined map of accepted and in-use detailed plans. Describes planned development and land-use in cities, on ward, block and plot level eg. the amount of previously developed and vacant land which may be available for re-development; where, how and what kind of buildings can be constructed; location, size, form, facade material, floor area and purposed use of buildings.	City of Vantaa / other municipalities	https://www.avoindata.fi/data/en_GB/dataset/vantaan-ajantasa-asemakaava	Open data			Borough	Map data, raster, municipal		Ongoing
Municipal building registers	Similar to Population Register Centre's building register, but municipalitys own. Accuracy may vary between municipalities.	Municipality	E.g.: https://hri.fi/data/dataset/vantaan-rakennukset, https://kartta.hel.fi/paikkatietohakemisto/?id=286	Partly public			Point location	municipal		Ongoing
MATTI-system	Demolished buildings. In a development phase; not yet in use	City of Vantaa		Private				Municipal		

LONDON DATA SOURCES - BUILDING STOCK										
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**	**Format**	**Units**	**Smallest geography**	**Volume of data**	**Time range & frequency of data collection**	**Ongoing/ Inactive/ Not yet active**

London Development Database	The London Development Database records significant planning permissions in London, including: • Any new build residential units •Any loss or gain of residential units through change of use or conversion of existing dwellings •Creation of seven or more new bedrooms for use as either a hotel, a hostel, student housing or for residential care through new build or change of use •1,000m2 or more of floor space changing from one use class to another or created through new build or extension for any other use •The loss or gain or change of use of open space. The LDD provides data on number of planning permission cases that are completed, started and not yet started, and gives precise information on location. Where SWMPs have been submitted, these will provide a precise idea of waste arisings and routes. NB City Hall is not responsible for adding any information to the database (this is done by local authorities), or for the quality or completeness of data. Also see article for information on data quality. See also the LDD Automation Project, which intends to be a 'live hub' of publicly accessible data and information on planning and development, hoped to be implemented in 2020. Achieved by requesting the data required for monitoring up-front on the initial planning application. This could be a highly valuable source of data, e.g. by allowing access to Waste Management Plans. Additionally, new planning policy may require further information related to circular construction, e.g. use of reclaimed materials.	Greater London Authority (GLA)	https://data.london.gov.uk/dataset/planning-permissions-on-the-london-development-database--ldd-	Open	XLS	Qualitative description	Postcode & point location	70621 cases at time of access	01.04.06 – present; Monthly (permissions) Annually (starts and completes)	Ongoing
Local Authority Development Information & Schedules	Local authority-held data on developments within boundaries, including major scheduled projects. See e.g. City of London, https://www.cityoflondon.gov.uk/services/environment-and-planning/planning/development-and-population-information/Pages/development.aspx	Varies	N/A	Varies	Unknown	Varies	Point location	Varies	Unknown	Ongoing

Valuation Office Agency Property Details Dataset	VOA collects and holds data on all domestic properties eligible for council taxation for valuation and maintenance of Council Tax lists. There was a bulk data capture exercise during 2003 and 2004 in England, which extracted and digitised property attributes of each dwelling from hard-copy records. Since then, the data are checked and updated whenever VOA visit the dwelling, or through their communications with billing authorities, builders, developers or the public. Data is gathered on the followed property attributes: • Unique Property Reference Number (UPRN, which may be used to derive location based on • OS Addressbase Data) • Address variables • Property type • Number of rooms • Number of bedrooms • Lowest floor level • Number of bathrooms • Total floor area • Built age of property • Central heating signal • Conservatory type • Conservatory area • Parking • Value significant codes • Source codes These may be used to ascertain numbers of different building typologies within a building stock segment within an area. Outputs are aggregated at the different geographic levels. See following link for declined FOIA request: https://www.ons.gov.uk/aboutus/transparencyandgovernance/freedomofinformationfoi/propertydetailsextractforenglandandwalesfor1april1993to1july2016	Valuation Office Agency (VOA)	https://www.ons.gov.uk/census/censustransformationprogramme/administrativedatacensusproject/datasourceoverviews/valuationofficeagencydata	License required	Unknown	Various	Point location			
London Building Stock Model	Attempt to compile a full spatial map of every building in London, including both actual and modelled EPC data to provide an idea of energy usage down to the level of the building. Compiles multiple existing datasets, including the UK Buildings Database, EPC register, OS data and private GLA data on energy efficiency of buildings. EPC modelling of data-less buildings being undertaken by UCL.	GLA	n/a	Combines both public and private datasets. Private GLA data will not be shared or made public.	n/a	n/a	Point location	Unknown	Not yet active	Not yet active

UK Buildings Database	Contains the location and footprint of all buildings across the UK with a full classification within urban areas (towns above 10,000 population). Features: • Basic residential/non-residential and mixed use classification • Detailed residential classification of building age and type • Residential structural characteristics based on age/type • Non-residential classification includes age, building use, and construction characteristics • Integrated with Ordnance Survey AddressBase via UPRN • Building heights and number of floors • Basements identified Useful for 3D mapping. Uses OS AddressBase. Available in mapping or database formate, or via API.	Geomni	https://www.geomni.co.uk/ukbuildings	Paid	GIS?	Multiple	Point location	All buildings	n/a	Ongoing
English Housing Survey	Annual survey of the characteristics and conditions of a random sample of homes, generally with around 13,000 cases from across the country. Includes a wide range of relevant variables, including dimensions, construction type, materials, build period, previous modifications to building, building components and services present, age of internal and external building elements (or components), internal / external defects, structural faults, housing health and safety rating, pests, drains, local area and environment, amongst others. Does not cover all homes, however is considered to be a representative sample.	BRE	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/860076/2018-19_EHS_Headline_Report.pdf	License-only	Unknown	Multiple	Postcode	~13,000 per year	1967-present; Annual	Ongoing

Energy Performance of Buildings Data	Open dataset of Domestic EPCs, Non-Domestic EPCs, Display Energy Certificates and Air Conditioning Inspection Reports. Whole file available for download (latest data for 31/8/19). Contains fields on: • Overall EPC rating and potential EPC rating • Location (address, postcode, LA, constituency) • Property type and form (e.g. house, semi-detached) • Inspection date • Floor area • Heating and lighting current costs, potential costs and efficiency • Heating system type (e.g. boiler and radiators from mains gas) • Glazing type and area • Floor height (i.e. storey height) • plus a few relevant others • RECOMMENDED IMPROVEMENTS (good for urban mining and transformation potential?) Updated two to four times per year. Official EPC register (https://www.epcregister.com/home.html) has current data and is the definitive store of EPC data, however it is not available as a single dataset, can only search for individual buildings and energy assessors.	MHCLG	https://epc.opendatacommunities.org/domestic/search	Open	XLS	Multiple	Postcode Local Authority	18.5m cases	2007 - present; Twice to four times per year	Ongoing
London Planning Data Map	Project to collate and share spatial planning data for the whole of London. The aim is to create a single map that can become the definitive source for London's planning data, providing site-specific information on planning designations. Contains data on: • Brownfield Registers • Site Allocations • Opportunity Areas • Town Centres • Areas of Intensification • Central Activities Zone • SHLAA approvals and allocations • Designated Open Space • Site of Importance for Nature Conservation • Sites of Special Scientific Interest • Flood Risk • Conservation Areas • Strategic Industrial Locations • Locally Significant Industrial Sites • Safeguarded Wharves • Article 4 Directions: Office to Residential • Protected vistas • Housing Zones • Creative Enterprise Zones All data will be available for download by the public.	Greater London Authority (GLA)	https://maps.london.gov.uk/planning/	N/A	Map	Polygons	Point location	N/A	Unknown	Ongoing

London Plan AMR planning data - housing	To check performance against the KPIs of the London Plan, an Annual Monitoring Report is compiled with relevant data, including: •Number of housing approvals for year passed •Number of housing starts for year passed •Number of housing completions for year passed •Housing pipeline For each entry, information is provided on (existing and, where relevant, proposed) number of residential units, floorspace, number of bedrooms, and site area. Data is drawn from the London Development Database (see row above).	GLA	https://data.london.gov.uk/dataset/london-plan-amr14-tables-and-data	Open	XLS	Multiple	Postcode & point location	Varies (multiple datasets available)	2016 - present; Annual	Ongoing
Age of Commercial and Industrial Stock	Dataset showing commercial and industrial building stock numbers, floor space and rateable value, split by age (pre-1940, 1940-1970, 1971-1980, 1981-1990, 1991-2000, 2001-2003, unknown) and class (factory, office, retail, warehouse)	Ministry of Housing, Communities and Local Govt (MHCLG)	https://www.gov.uk/government/statistical-data-sets/live-tables-on-commercial-and-industrial-floorspace-and-rateable-value-statistics	Open	XLS	#	Borough	Varies (multiple datasets available)	1998-2008; Annual	Inactive
Number of dwellings and net additional dwellings	Displays net additions to housing stock by borough and for London, other regions, and England as a whole. Also displays total dwelling numbers and # persons per dwelling. Merton-specific data features on Merton website. Appears that Merton gets their public data from MHCLG, the VOA etc.	MHCLG	https://data.london.gov.uk/dataset/net-additional-dwellings-borough	Open	XLS	#	Borough		2004 – present (net additions) 2001 – present (all dwellings) Updated annually	Ongoing
Council Tax: stock of properties, 2019	Range of datasets on the number of properties by property type, build period and council tax band. Available from national level down to LSOA. Data is provided to the VOA by local authorities, who are responsible for the actual data collection. However, on Merton's website the data they provide property stock data that is taken from this dataset? Could be useful for making estimates of resource stock where figures on typical bill of quantities within different property types and ages are available. Where likely refurbishment rate can be modelled, this data combined with material arisings benchmarks (from SmartWaste or similar)	VOA	https://www.gov.uk/government/statistics/council-tax-stock-of-properties-2019	Open	XLS	#	LSOA	Varies (multiple datasets available)	2019; Annual	Ongoing
Dwellings by Property Build Period and Type, LSOA and MSOA	Dataset displays number of dwellings within each build period (Pre-1900, 1900-1918, 1919-1929, 1930-1939, 1945-1954, 1955-1964, 1965-1972, 1973-1982, 1983-1992, 1993-1999, 2000-2009, 2010-2012) Split by type (e.g. flat, bungalow, etc. by # of bedrooms) and by council tax bands. Detail provided down to the LSOA level.	VOA	https://data.london.gov.uk/dataset/property-build-period-lsoa	Open	XLS	#	LSOA		2015 only	Inactive

Dwelling stock by tenure and condition	Provides counts of dwellings in each borough, with tenure grouped into LA-owned, registered social landlord-owned, other public owned, owner occupied and private rented dwelling. Condition is given as proportion of LA dwellings that fall below the “decent home standard”.	Office for National Statistics (ONS)	https://data.london.gov.uk/dataset/dwelling-stock-tenure-and-condition-borough	Open	XLS	#	Borough		2001-2011; Annual	Inactive
Registered social landlord housing stock	Provides counts of the number of social landlord-owned self-contained units or bed-space.	GLA	https://data.london.gov.uk/dataset/registered-social-landlord-housing-stock	Open	XLS	#	Borough		1997-2018; Annual	Inactive
Commercial and Industrial Floorspace	Breakdown of commercial and industrial stock including count, floorspace and rateable value, split according to sector: retail, offices, industrial and other.	VOA	https://data.london.gov.uk/dataset/commercial-and-industrial-floorspace-borough	Open	XLS	#	Borough	33	2000-2012; Ad-hoc (not updated for 5 years)	Inactive
Non-Domestic Rating: Stock of properties including business floorspace	Number, rateable value, and floorspace of non-domestic properties, split by area and type of non-domestic building (retail, offices, industrial, other).	VOA	https://www.gov.uk/government/statistics/non-domestic-rating-stock-of-properties-including-business-floorspace-2019	Open	XLS	#	LSOA	Varies (multiple datasets available)	2000-present; Annual	Ongoing
Plot Ratios in Industrial Developments	Lists all planning permissions granted to industrial developments between 1/4/11 and 28/2/18 (completed, lapsed, started, not yet started, and superseded). Provides info on plot area ratio (gross floor area of all floors of a building divided by area of the building lot), total floorspace of built site, maximum # of storeys (in some cases), proposed area of residential and non-residential site, existing area of greenfield land, proposed open space and site area, existing and proposed # of residential units, existing and proposed # bedrooms, and various others.	GLA	https://data.london.gov.uk/dataset/plot-ratios-in-industrial-developments-april-2011---february-2018	Open	XLS	Multiple	Individual property; Point location	401 records	2011-2018	Inactive
OS AddressBase (basic, pro, premium)	Basic AddressBase has csv data on Royal Mail postal addresses, where matched to a UPRN and coordinates for each address. AddressBase Plus has the above plus Local authority Bs7666 addresses, objects without postal addresses, addresses with multiple occupants, OS MasterMap Topography Layer and Integrated Transport Network TOIDs, and the associated alternative record. AddressBase Premium has the above plus Pre-build addresses, historic addresses, and, alternative addresses.	Ordnance Survey	Basic : https://www.ordnancesurvey.co.uk/business-government/products/addressbase Plus: https://www.ordnancesurvey.co.uk/business-government/products/addressbase-plus Premium: https://www.ordnancesurvey.co.uk/business-government/products/addressbase-premium	License needed for all types	CSV	Multiple	Individual property; Point location	Every UK address	Unknown; Every 6 weeks	Ongoing

OS Building Height Attribute	Database of building heights in UK developed in response to customer demand for height information for buildings and select structures. It can be used to make simple 3D visualisations of buildings and structures and can be used to assist a range of analytical applications across both public and commercial sectors.	Ordance Survey	https://www.ordnancesurvey.co.uk/business-government/products/mastermap-building	License required	CSV	Multiple	Individual property; Point location	Every UK building	Unknown	Ongoing
Generalised Land Use Database (GLUD)	Land Use Statistics by ward as of 2005 using GLUD. Uses include area (and % of total area) covered by domestic buildings, gardens, non-domestic buildings, greenspace, paths, rail, road and water.	MHCLG	https://data.london.gov.uk/dataset/land-use-ward	Open	CSV, XLS	000's m2 %	Ward	~620	2005 only	Inactive
Historic Landscape Characterisation	Database of land use polygons. For each polygon, database record is typically divided into several tabs: Description, Attributes, Previous Type(s), Monuments, Sources. See URL for full description of the types of information provided under these tabs. There is a specific type of HLC for urban areas, the Metropolitan HLC. NB there doesn't appear to be a publicly available HLC for London. In cases where it has not been made publicly available, an HLC is usually held by a local Historic Environment Record, but in a London HER report it states that they only have a partial HLC.	Historic England	https://historicengland.org.uk/research/methods/characterisation-2/historic-landscape-characterisation/#Section2Text	Not open	Unknown	Polygons	Individual property; Point location	Unknown	Unknown	Ongoing
Local units by Broad Industry Group	Count of business units, split by business sector.	ONS	https://data.london.gov.uk/dataset/local-units-broad-industry-group-borough	Open	XLS	#	Borough	Varies (multiple datasets available)	2003 – 2019; Annual	Ongoing
Number of vacant dwellings	The data provide information on vacant dwellings, by period vacant and second homes, and were produced from Local Authority (LA) Council Tax systems.	MHCLG	https://data.london.gov.uk/dataset/vacant-dwellings?resource=c428a18b-9961-4b98-9cfe-b7f120114141	Open	XLS	#	Borough	Number per year per borough, under 6 categories; ~2800 enries	2004 – 2019; Annual	Ongoing
Commercial and industrial property vacancy statistics	Estimated vacancy rates by percentage, for commercial and industrial properties.	MHCLG	https://data.london.gov.uk/dataset/commercial-and-industrial-property-vacancy-statistics-borough?resource=f2a94f0f-5ac6-40a2-a27b-adc84c8145a4	Open	CSV, XLS	#	Borough	~300	1998 - 2005; Annual	Inactive
Domestic Energy Efficiency Ratings	Data from certificates lodged on the Energy Performance of Buildings (EPB) Registers, i.e. on buildings which have been newly constructed, sold or let since 2008. Includes information on average energy efficiency ratings, energy use, carbon dioxide emissions, fuel costs, average floor area sizes and numbers of certificates recorded. Split according to dwelling type.	MHCLG	https://data.london.gov.uk/dataset/domestic-energy-efficiency-ratings-borough	Open	XLS	#	Borough	~9000 entries	2008 - 2019; Quarterly	Ongoing

COPENHAGEN DATA SOURCES - ENABLERS							
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**	**Smallest geography**	**Time range & frequency of data collection**	**Ongoing/ Inactive/ Not yet active**
Danmark uden affald II (Denmark without waste 2)	Waste Prevention Strategy (April 2015)	The goverment	https://www.ft.dk/samling/20141/almdel/MIU/bilag/270/1525187.pdf				

HAMBURG DATA SOURCES - ENABLERS							
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**	**Smallest geography**	**Time range & frequency of data collection**	**Ongoing/ Inactive/ Not yet active**
Borough development/local plans and area action plans/neighbourhood plans	The aim of the map "Cooperation projects with neighbouring communities and districts in Hamburg" is to communicate projects and activities for cross-border cooperation. The interactive map uses various symbols to represent cooperation projects between Hamburg and its neighbouring municipalities and districts in which the Hamburg Ministry of Urban Development and Environment or a Hamburg district is involved. The map is limited to three zoom levels. Each project shown is assigned to one of seven categories, each represented by a symbol: Development concepts, neighbourhood forum, regional park, urban development project, nature conservation project, transport project, regional workshop. By clicking on a symbol, the user receives brief information about the concrete project, the Hamburg contact and, if applicable, the corresponding link to the project page. The map is continuously updated by the Department of Urban Development and Environment (Department of Regional Planning and Regional Development).		https://metaver.de/trefferanzeige?docuuid=C8BC68C7-EA57-4147-AC23-BC41E0A2DC80	Public	Borough	last actualisation 05/2012	Inactive
City-level planning applications and decisions	Selected completed housing projects are presented with a short description and a picture. The information is also linked to a project page on hamburg.de.		https://metaver.de/trefferanzeige?docuuid=2E74D411-814C-4E65-9C9F-861517B5F393	Public	Point location	2014	Inactive

Hamburgisches Abfallwirtschaftsgesetz	Hamburg Waste Management Law		http://www.landesrecht-hamburg.de/jportal/portal/page/bshaprod.psml?showdoccase=1&doc.id=jlr-AbfWGHA2005rahmen&st=lr	Public			
Hamburgische Bauordnung	Hamburg building regulations		http://www.landesrecht-hamburg.de/jportal/portal/page/bshaprod.psml?showdoccase=1&doc.id=jlr-BauOHA2005rahmen&st=lr	Public			
Bauvorlagenverordnung	Building documents regulation		http://www.landesrecht-hamburg.de/jportal/portal/page/bshaprod.psml?showdoccase=1&doc.id=jlr-BauVorlVHA2010rahmen&st=lr	Public			
Richtlinie der Bund-Länder-Arbeitsgemeinschaft Abfall (LAGA)	Guideline of the Federal and State Working Group on Waste		https://www.laga-online.de/documents/m34_vollzugshinweise_gewabfv_endfassung_11022019_inh-red_aenderung_1554388381.pdf	Public			
Hamburger Klimaplan	Climate Plan (p.21)		https://www.hamburg.de/contentblob/13287332/bc25a62e559c42bfaae795775ef1ab4e/data/d-erste-fortschreibung-hamburger-klimaplan.pdf	Public			

Gemeinsamer Abfallwirtschaftsplan für Bau- und Abbruchabfälle von Hamburg und Schleswig-Holstein AWP	Joint waste management plan for construction and demolition waste of Hamburg and Schleswig-Holstein AWP		https://www.hamburg.de/contentblob/13094498/15981edf568897430a0865e52b4a4c00/data/d-entwurf-awp-bau-oeffent-auslegung-2019.pdf	Public			

HELSINKI DATA SOURCES - ENABLERS							
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**	**Smallest geography**	**Time range & frequency of data collection**	**Ongoing/ Inactive/ Not yet active**
Vantaa roadmap to resource wisdom	Guides the development of the city towards a city with no emissions and no waste, using natural resources sustainably and without overconsumption. Defines i.a. that construction in Vantaa should take energy efficiency, eco-efficiency and environment as their core values and to preserve and increase the biodiversity of nature, as well as to ensure functioning ecosystem services. Sets a goal of carbon neutral Vantaa by 2030.	City of Vantaa	https://www.vantaa.fi/instancedata/prime_product_julkaisu/vantaa/embeds/vantaawwwstructure/144023_Resurssiviisaus_englanti_web.pdf	Public		2019 - 2030	
Carbon neutral Helsinki 2035	Sets a goal of carbon neutral Helsinki by 2035. Requires energy efficient buildings and taking the entire carbon footprint of construction into account and promoting wooden construction	City of Helsinki	https://www.hel.fi/static/liitteet/kaupunkiymparisto/julkaisut/julkaisut/HNH-2035/Carbon_neutral_Helsinki_Action_Plan_1503019_EN.pdf	Public		2018 - 2035	
Sustainable Espoo development programme	Program sets goals to support the development and implementation of economically, ecologically, socially and culturally sustainable solutions. Carbon neutrality by 2030 is one of the key objectives in the program. It defines the guidelines for battling climate change until 2020. It sets goals to i.a. expedite repair, additional and complementary construction and to promote the commissioning of renewable energy sources.	City of Espoo	https://www.espoo.fi/en-US/City_of_Espoo/Decisionmaking/The_Espoo_Story/Sustainable_Espoo https://www.espoo.fi/en-US/Housing_and_environment/Sustainable_development/Climate_goals	Public		2017-2021	

Helsinki Metropolitan Area Climate Strategy	The goal of the climate strategy is a common vision and appreciation of operating policies to reduce greenhouse gas emissions in the Helsinki Metropolitan Area. The aim of the jointly formulated vision is to guide city planning and policymaking towards congruent operating policies and methods. Building design, development and use are guided by whole life cycle costs, energy efficiency, versatility and degree of use.	HSY	https://www.hsy.fi/sites/Esitteet/EsitteetKatalogi/Raportit/Helsinki_Metropolitan_Area_Climate_strategy_summary.pdf	Public		2007-2030	

LONDON DATA SOURCES - ENABLERS							
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**	**Smallest geography**	**Time range & frequency of data collection**	**Ongoing/ Inactive/ Not yet active**
London Environment Strategy	Sets out Mayor's environmental ambitions, two of the seven themes are 'Low-carbon circular economy' and 'Waste'	GLA	https://www.london.gov.uk/what-we-do/environment/london-environment-strategy				
INSPIRE	The INSPIRE (Infrastructure for Spatial Information in Europe) Directive aims to create a European Union spatial data infrastructure for the purposes of EU environmental policies and policies or activities which may have an impact on the environment. This European Spatial Data Infrastructure will enable the sharing of environmental spatial information among public sector organisations, facilitate public access to spatial information across Europe and assist in policy-making across boundaries. INSPIRE is based on the infrastructures for spatial information established and operated by the Member States of the European Union. The Directive addresses 34 spatial data themes needed for environmental applications. The Directive came into force on 15 May 2007 and will be implemented in various stages, with full implementation required by 2021.	EU project	https://inspire.ec.europa.eu/				

Smarter London Together	Roadmap to make London ‘the smartest city in the world’, launched by the Mayor. "This roadmap is intended to be a flexible digital masterplan for the city. It sets out how we want to collaborate with the capital's boroughs and services, from TfL to the NHS. We also want to work more effectively with the tech community, our universities and other cities. We see London’s future as a global test-bed city for innovation where the best ideas - eg from the AI sector - are developed here with the highest standards for privacy and security, and spread around the world. We’ll do this in five missions: design, data sharing, connectivity, skills, and collaboration." Amongst these 5 missions, some relevant objectives include: • Launch the London Office for Data Analytics (LODA) programme to increase data sharing and collaboration for the benefit of Londoners. • Support an open ecosystem to increase transparency and innovation • Support a new generation of smart infrastructure through major combined procurements • Establish a London Office of Technology & Innovation (LOTI) to support common capabilities and standards for future innovation • Collaborate with other cities in the UK and globally to adopt and share what works	GLA	https://www.london.gov.uk/what-we-do/business-and-economy/supporting-londons-sectors/smart-london/smarter-london-together				

Borough development/local plans and area action plans/neighbourhood plans	MERTON LOCAL/DEVELOPMENT PLAN (INCL INFRASTRUCTURE) Planning frameworks and policies that set out future development (usually 15-20 years?) for boroughs as a whole (in the case of development/local plans), as well as at a more granular level for neighbourhoods and other significant areas earmarked for development within boroughs (in the case of area action plans/neighbourhood plans), such as town centres. Available for each borough (see e.g. Camden Local Plan; Old Oak and Park Royal Development Corporation Local Plan), with area action plans and neighbourhood plans developed for specific locations (e.g. Old Kent Road Area Action Plan). These provide estimates for the scale and locations of development, as well as the types of development. NB these must be in general conformity with the London Plan and must be consistent with the NPPF and NPPG.	Local authorities	n/a	Public	n/a	Varies	Ongoing
GLA Population and Household Projections	Projections of future population and housing stock to 2050. See excel file: “Housing-led population projection”, sheet name “Housing stock”	GLA	https://data.london.gov.uk/dataset/projections	Public	Borough		Ongoing
Flexible working	Numbers of people with a flexible working arrangement (linked with circular economy due to lower building office space requirements).	ONS	https://data.london.gov.uk/dataset/flexible-working	Public	City	2010 – 2017; Annual	
London Plan: Construction, excavation aInd demolition waste	Chapter 5, Policy 5.18	GLA	https://www.london.gov.uk/what-we-do/planning/london-plan				
London Plan: Sustainable design and construction	Policy 5.3 Suggests design principles to include ‘efficient use of natural resources (including water), including making the most of natural systems both within and around buildings’; ‘minimising the generation of waste and maximising reuse or recycling’; and, ‘securing sustainable procurement of materials, using local supplies where feasible’.	GLA	https://www.london.gov.uk/what-we-do/planning/london-plan				
London Plan KPI: Increase supply of new homes	Target: Average completion of a minimum of 42,000 net additional homes per year.	GLA	https://www.london.gov.uk/what-we-do/planning/london-plan				

London Plan: Areas for regeneration / Opportunity Areas / Intensification Areas	Areas for Regeneration: OAs: Brownfield sites identified as having significant capacity for development – such as housing or commercial use – and existing or potentially improved public transport access. Typically, they can accommodate at least 5,000 jobs, 2,500 new homes or a combination of the two, along with other supporting facilities and infrastructure. IAs: built up areas with good existing or potential public transport links and can support redevelopment at higher than existing densities. They have significant capacity for new jobs and homes but at a level below that which can be achieved in the Opportunity Areas.	GLA	https://data.london.gov.uk/dataset/london-plan-opportunity-areas https://data.london.gov.uk/dataset/areas_of_intensification				
London Infrastructure Plan	Sets out the scale of the challenge for meeting the needs of a rapidly growing city, and the need to ensure that London's infrastructure is developed in line with the principles of the circular economy achieving the greatest economic and environmental benefits. Circular economy is a cross-cutting theme. Called for development of the London Infrastructure Mapping Application.	GLA	https://www.london.gov.uk/what-we-do/business-and-economy/better-infrastructure/london-infrastructure-plan-2050				
Local Cultural Infrastructure Plans	The draft New London Plan and the Mayor's Cultural Infrastructure Plan encourage local authorities to invest in cultural infrastructure and develop local cultural infrastructure policies, potentially providing a non-specific idea of the scale and location of future material needs.	GLA	https://www.london.gov.uk/what-we-do/arts-and-culture/culture-and-good-growth/cultural-infrastructure-plan				
Digital data standard formats	These are commonly used to produce a detailed list of building components (and their material constituents) using standard classes and units of measurement. Common ones include: • Industry Foundation Classes (IFCs). Standard: ISO 16739-1:2018. • COBie files (may be extracted from or fed into IFC) - spreadsheet format. Data is gathered and released at least 5 times across a construction project lifecycle. • Uniclass 2015						

Uniclass	Consistent classification structure for all disciplines in the construction industry. It contains tables classifying items of any scale from a large facility such as a railway, down to products such as a CCTV camera in a railway station. It is a way of identifying and managing the vast amount of information that's involved in a project, and it's a requirement for BIM projects, as set by the BS EN ISO 19650 series of standards.	Construction Project Information Committee (CPIC)	https://www.thenbs.com/our-tools/uniclass-2015				
Waste processing facility Gate Fees	Charge levied upon a given quantity of waste received at a waste processing facility. Varies according to waste stream. DEFRA EPR project collected average gate fees for a range of CDW streams for the south of England from Reconomy, however it would also be possible to gather London- and potentially borough-specific data from them also.	Reconomy	Link to averages for DEFRA project (private)				
City of London Directory of Local Construction SMEs	Directory of Construction related subcontractors and suppliers that are small and medium sized enterprises (SMEs) and based in the City and neighbouring boroughs. Intended to help satisfy S106 local procurement obligations and encourage responsible sourcing. Currently around 130 SMEs listed covering over 70 trades and services.	City of London	https://www.cityoflondon.gov.uk/business/responsible-city/Documents/directory-of-construction-SMEs-in-the-city-v2.pdf				
EU Waste Statistics Regulations reporting - data collection methodology	Data for reporting comes from non-WDI EA data, WasteDataInterrogator, trade association data, Defra stats, national packaging waste database returns (held by EA), wood recyclers association data, and WasteDataFlow. Therefore, to find out where Eurostat data from WStatR reporting comes from, need to go to these sources.	katie.fisher@defra.gsi.gov.uk	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/778779/CommercialandIndustrial_WasteArisings_Methodology_Revisions_Feb_2018_Oct_2018_rev2_update.pdf				
Merton Local Plan - Development Plan	Setting out spatial vision, objectives, strategic and detailed planning policies and site allocations. Replacing Merton's Sites and Policies Plan 2014; Merton's Core Planning Strategy 2011 and Merton's Policies Map (where relevant) 2014. Consultations ongoing; submission due summer 2021; adoption by winter 2021.	Merton Borough Council	https://www.merton.gov.uk/assets/Documents/Local%20Development%20Scheme%20%202019%20.%202022.pdf				

Environmental Permitting Regulations - Waste Operations	Waste operations require an environmental permit if the business uses, recycles, treats, stores or disposes of waste or mining waste. The permit can be for activities at one site or for mobile plant used at many sites. Register of these permits which is searchable by local authority (borough).	Environment Agency	https://environment.data.gov.uk/public-register/view/search-waste-operations				
Waste Local Plans	local plan in line with article 28 of the Waste Framework	Gov.uk	nvironment/waste/pla				

COPENHAGEN DATA SOURCES - INFRASTRUCTURE STOCK										
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**	**Format**	**Units**	**Smallest geography**	**Volume of data**	**Time range & frequency of data collection**	**Ongoing/ Inactive/ Not yet active**
The Copenhagen Map (Københavner kortet)	Interactive maps over new and existing infrastructure projects	Copenhagen municipality	https://kbhkort.kk.dk/spatialmap?	Public	PDF		Building block	Copenhagen		Ongoing
km of different road types	Database VEJ11: Road network 1st January by part of the country and type of road	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=VEJ11&PLanguage=1	Public	Excel		Region	Denmark	2007 - present; 1st January	Ongoing
km of different road types (old)	Database VEJ1: Road network 1st January by county and type of road (DISCONTINUED)	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=VEJ1&PLanguage=1	Public	Excel		Old regions	Denmark	1990-2007; 1st January	Inactive
Investments in the road devided between new construction and maintenance (DKK)	Database VEJ2: Investments in the road network by type of investment and unit	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=VEJ2&PLanguage=1	Public	Excel		Region	Denmark	1990 - present; 1st January	Ongoing
Km of different railway networks (metro, S-train, main arterias)	Database BANE41: Railway network 1st January by railway system and unit	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=BANE41&PLanguage=1	Public	Excel		Denmark	Denmark	1990 - present; 1st January	Ongoing
Investments in the railways (DKK)	Database BANE42: Investments in railway network by type of investment and unit	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=BANE42&PLanguage=1	Public	Excel		Denmark	Denmark	1990 - present; 1st January	Ongoing
Km of pipelines	Database ROR1: Pipeline network by type of pipelines	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=ROR1&PLanguage=1	Public	Excel		Denmark	Denmark	1981 - present; 1st January	Ongoing
Investments in the pipeline network (DKK)	Database ROR2: Investments in the pipeline network by type of pipeline and unit	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=ROR2&PLanguage=1	Public	Excel		Denmark	Denmark	1980 - present; 1st January	Ongoing

HAMBURG DATA SOURCES - INFRASTRUCTURE STOCK										
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**	**Format**	**Units**	**Smallest geography**	**Volume of data**	**Time range & frequency of data collection**	**Ongoing/ Inactive/ Not yet active**
Population data on districts in Hamburg	Statistical data on population and social structure in Hamburg districts on 31.12.2014 of the Statistics Office North. The population by age and foreigners are taken from the population register as at 31.12.2014 and comprise only main and sole residences. The population density in km² is based on the same source as well as on the planimetric area of the regional office for geoinformation and surveying. The population with a migration background was determined from the population register 31.12.2014 (only main residence) by estimates with MigraPro. The household data were determined from the population register 31.12.2014 by estimates with HHGen. The share of single parent households refers to all households with children. The employment rate includes employees subject to social insurance contributions at the place of residence in December 2014 of the Federal Employment Agency and refers to the employable population aged 15 to under 65 from the population register of 31 December 2014.The unemployment rate includes the unemployed according to SGB II and SGB III in December 2014 of the Federal Employment Agency and refers to the employable population aged 15 to under 65 from the population register 31.12.2014.		https://metaver.de/trefferanzeige?docuuid=C2B674ED-73DB-4D29-9955-8621C1B5906A	Open			Borough		2014	Inactive
Heat register	Every building that is not yet located in an area with an existing heating network was fictitiously connected to a hypothetical heating network. The hypothetical heating network provides information on the heat line density per street section.		https://metaver.de/trefferanzeige?docuuid=D72E73FB-97A0-45DD-BE51-DE9C4EB5C4C2	Open			Point location		April 2019	Ongoing
INSPIRE HH Verkehrsnetze ALKIS	This dataset contains the Hamburg transport networks: road, rail, air and water from the ALKIS source model and represented in the INSPIRE target model. The basis for ALKIS® is a technical concept developed by the Working Group of the Surveying Authorities of the States of the Federal Republic of Germany (AdV) for the management of all basic data of the official surveying system.		https://metaver.de/trefferanzeige?docuuid=1BD1BACC-6E6C-40E2-9B29-3B851CD6CFB5	Open			Point location		2017	Ongoing
Bridges and other civil engineering works Hamburg	Existing buildings in the area of responsibility of the LSBG with information on location, ASB number, internal building number, building name and year of construction. The following buildings are listed: Road bridges, pedestrian bridges, tunnels, noise protection walls, retaining walls and sign bridges.		https://metaver.de/trefferanzeige?docuuid=3645B69F-2C00-4DD0-937D-D9D567F8A6A6	Open			Point location		2017	Ongoing

Potential Areas in regional planning	In the database PAUL (Information on potential areas in regional planning) at BSU/LP 1, the residential and commercial property potentials of Hamburg are recorded on an urban level. The database serves to monitor the potential of residential and commercial areas, to support internal decision-making and to advise the Senate and the BSU authorities on policy. The database is available on the intranet to the specialist authorities and districts for reading access.		PAUL Database	acces restricted, only for administration			Borough			Active
Heat demand	The data set "Heat demand" of the heat register represents the heat demand of the Hamburg building stock in aggregated form. The heat demand of the Hamburg building stock is displayed at building block level and at cluster level. In addition, you can choose between two refurbishment levels: 1. unrefurbished" implies a building condition which does not show any thermal modernisation (apart from a simple window replacement) 2 "Refurbished" assumes conventional refurbishment of all buildings (according to ENEV 2014). The representation and categorisation can be selected as follows: 1. total demand of all residential and non-residential buildings of the cluster or building block unit; in megawatt hours per year [MWh/a]. 2. specific heat demand of the residential buildings (cluster); in kilowatt hours per square metre of usable area and year [kWh/m² a]. 3. thermal density in the building block; total demand of all residential and non-residential buildings (as no. 1) divided by the floor area of the respective building block; in kilowatt hours per square metre of building block floor area and year [kWh/m² a].		https://metaver.de/trefferanzeige?docuuid=490217DC-8899-4D70-80A2-E0C1EBDAC8DE	Open			Borough		2016, last change in 2018	Ongoing
Integrated district development - RISE - assisted areas in Hamburg	The map shows the areas eligible for funding under the Hamburg Framework Programme for Integrated Urban District Development (RISE). RISE forms the programmatic umbrella for urban development funding at state level. It comprises the areas of federal and state urban development funding in the programme areas of Social City, Urban Redevelopment, Active Urban and District Centres, Urban Heritage Conservation and Future Urban Green Areas as well as redevelopment areas. Further information: www.hamburg.de/rise		https://metaver.de/trefferanzeige?docuuid=0B04AC26-6602-49A2-93D0-75531B1A2FC5	Open			Borough		Last change in 2019	Ongoing

HELSINKI DATA SOURCES - INFRASTRUCTURE STOCK										
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**	**Format**	**Units**	**Smallest geography**	**Volume of data**	**Time range & frequency of data collection**	**Ongoing/ Inactive/ Not yet active**
DigiRoad - National Road and Street Database	Digiroad data consists of the center line geometry of the transport network, traffic-related attribute data and other transport system objects, i.a. length, width, type of surfacing, lightning, bridges, tunnels, lit roads, bus stops, traffic lights, traffic volumes. Covers the vehicle-accessible roads, ferry and cable ferry connections for cars, railways and separate pedestrian and cycle routes. *Notes* : Not 100% comprehensive for private roads	Finnish Transport Infrastructure Agency	https://vayla.fi/web/en/open-data/digiroad#.XiGMluQUmZ8	Open data				Map data, national		Ongoing
Road register	Includes time-series data on the state of roads and traffic in the public road network by region. Length, width, type of surfacing. Includes only roads belonging to Transport Infrastructure Agency, no streets nor private roads.	Finnish Transport Infrastructure Agency	https://vayla.fi/palveluntuottajat/aineistot/tierekisteri#.XiF7xOQUmZ-	Requires access rights from FTIA			Point location	National		Ongoing
Bridge register / Special structure register	Data of i.a. bridges, tunnels, canals, (road) landing places.Area, length, main building material, condition class.	Finnish Transport Infrastructure Agency (FTIA)	https://www.suomi.fi/palvelut/taitorakennerekisteri-vaylavirasto/a5fbb6b3-5fd1-4c26-9b6b-f9fabe84e013	Requires access rights from FTIA				National		Ongoing
Road statistics	Time series data of traffic, road network and accidents.	Traficom	https://www.traficom.fi/fi/tilastot/tietilasto	Open data				road district, some municipal and regional data	2009- present; Annual	Ongoing
Network Statement, Railways	Describes the state-owned rail network, the access conditions, the rail capacity allocation process, the services supplied to railway undertakings, and the principles of determing the infrastructure charge. Length of railways, stations, basic structures (materials).	Finnish Transport Infrastructure Agency (FTIA)	https://vayla.fi/web/en/commercial-railway-transport/network-statement#.XiGjo-QUmZ9	Open data				National	Annual	Ongoing
Railway statistics	Data of railways, rail traffic, rail equipment, financing and accidents. Length of railways, division of railways to passenger traffic and other, basic structures (materials), amounts of level crossings.	Traficom	https://www.traficom.fi/fi/tilastot/rautatietilasto	Open data				Partly map data. Covers the whole Finnish railway system.	Annual (previously provided by FTIA until 2018)	Ongoing
Municipal Infrastructure registers	Multiple data sets, varies between municipalities	Municipality		Partly public				Municipal		
SeutuMaisa	SeutuMaisa-tool aims to offer a common regional GI-database and a landmass information system that aims to help to manage the landmasses of the capital region. SeutuMaisa will calculate statistics about the amounts of excavated material and locations of the excavation works. Pilot phase of the project will run until the end of 2020. Continuation of SeutuMaisa after 2020 is unclear.	HSY	https://www.hsy.fi/fi/asiantuntijalle/seututieto/hankkeet/Sivut/SeutuMaisa.aspx	Pilot phase private			point location	Map data, database, Helsinki Metropolitan area	Present	Ongoing

LONDON DATA SOURCES - INFRASTRUCTURE STOCK										
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**	**Format**	**Units**	**Smallest geography**	**Volume of data**	**Time range & frequency of data collection**	**Ongoing/ Inactive/ Not yet active**
OS Open Roads / MasterMap Highways Network	Ordnance Survey GIS data on road network. Uncertain whether data can be aggregated by area to view details on total length, area and type of road within a location (from which material stock and arisings may be estimated based on material intensity and typical arisings (if these are known - unlikely).	Ordnance Survey	OS open roads: https://www.ordnancesurvey.co.uk/business-government/products/open-map-roads ; Highways Network: https://www.ordnancesurvey.co.uk/business-government/products/mastermap-highways	Open roads - Open Highways network - License required	GML, ESRI Shapefile	Vector	Point location	Unknown	Unknown	Ongoing
London Infrastructure Mapping Application	Displays geolocated data on upcoming energy, transport, water, civic, commercial/retail, education, medical/health, and residential projects, to a high level of spatial and temporal granularity. Also includes contextual layers such as air quality, boundaries, policy areas, environmental factors, social factors and more. Provides details on planning status. Underlying data comes from various sources with varying levels of accessibility, however this platform demonstrates that there is granular data out there on major upcoming infrastructure development.	GLA	https://www.london.gov.uk/what-we-do/business-and-economy/better-infrastructure/london-infrastructure-map	Underlying data accessibility varies	Shapefile	Varies	Point location	Unknown	2015 - 2050; Varies	Ongoing
Street Works UK	As the UK's only Trade Association representing utilities and their contractors on street works issues, we promote best practice, self regulation and a two-way relationship with Government and other relevant stakeholders. Street Works UK is also the utility arm of the Highway Authorities and Utilities Committee (HAUC(UK)), working collaboratively with roads / local authorities and national and regional governments to drive up standards of road and street works in Scotland, England, Northern Ireland and Wales.		http://streetworks.org.uk/resources/							
National Rail Infrastructure Returns	Reports with associated datatables on some info about UK rail infrastructure (including length of track, condition of track, and numerous other fields)	Office of Rail and Road (ORR)	https://www.networkrail.co.uk/who-we-are/publications-and-resources/regulatory-and-licensing/annual-return/	Public	Report	Multiple	National	Small	2018; Annual	Ongoing

Rail Infrastructure and Assets Statistical Release	Reports and associated data tables on national-level figures and statistics on: - Total km of track - Track electrification rate - Number of (additional) stations - Average age of rolling stock	Office of Rail and Road (ORR)	https://dataportal.orr.gov.uk/statistics/infrastructure-and-emissions/rail-infrastructure-and-assets/	Open	Report; XLS	Multiple	National	Small	1985 - 2019; Annual	Ongoing
Large infrastructure projects – ongoing and upcoming	E.g. HS2; Crossrail; Thames Tideway; Northern and Metropolitan Line extensions; Heathrow extension. Data may be available from developers, contractors and local authorities.	Various	n/a	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Potential Strategic Importance planning applications and decisions	Planning applications of Potential Strategic Importance (generally large buildings and developments) are referred by local authorities to the Mayor for decision or referral back to the LA. Information on the status of the application and decision is provided. Often includes fairly detailed qualitative information on works to be undertaken. NB this data shows applications, not decisions.	GLA	https://www.london.gov.uk/what-we-do/planning/planning-applications-and-decisions/current-planning-applications	Open	XLSX	Qualitative description	Point location	>10,000	2016 - present; Weekly	Ongoing
GLA Group Land Assets	Datasets showing the location of land and property holdings of GLA, London Fire Brigade, London Legacy Development Corporation, Met Police Service and TfL, plus development opportunities.	GLA	https://data.london.gov.uk/dataset/gla-group-land-assets	Open	CSV	Multiple	Point location / postcode	Varies (multiple datasets available)	2018 only	Unknown
Generalised Land Use Database (GLUD)	Land Use Statistics by ward as of 2005 using GLUD. Uses include area (and % of total area) covered by domestic buildings, gardens, non-domestic buildings, greenspace, paths, rail, road and water.	MHCLG	https://data.london.gov.uk/dataset/land-use-ward	Open	CSV, XLS	000's m2 %	Ward	~620	2005 only	Inactive
National Polygon Service	Dataset shows the indicative shape and position of each boundary of a registered title for land and/or property in England and Wales. Every title, whether freehold or leasehold, has at least one index polygon. Data includes: - shape - polygon identification - title number - date when polygon was created - update date (date when all or part of the title was last updated) - version of polygon identification number - record status (indicates aditions, changes and deletions to the records)	HM Land Registry	https://www.gov.uk/guidance/national-polygon-service#national-polygon-dataset	Paid	CSV	Multiple	Point location	>25 million	Unknown - 2016	Unknown

COPENHAGEN DATA SOURCES - LAND USE										
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**	**Format**	**Units**	**Smallest geography**	**Volume of data**	**Time range & frequency of data collection**	**Ongoing/ Inactive/ Not yet active**
Database for District Plans	Contains all local development plans with special requirements for new buildings or changes to existing buildings. There can also be requirements about types of buildings (industrial vs residential), allowed covered area, green spaces or special requirements for roof or wall materials.	Erhvervsstyrelsen (Danish Business Authority)	https://visplaner.plandata.dk/	Public	PDF		Building blocks or neighbourhood	Most of Denmark covered	Ongoing. New plans added when areas are developed	Ongoing
Copenhagen development plan (Finger plan)	First finger plan is from 1947. The newest is from 2019. The purpose with the plan is to: 1) Concentrate on housing, commerce, businesses, public institutions, etc. around a well-developed infrastructure in the finger village. 2) Reserve green areas, smaller urban communities, agriculture, etc. between and outside the finger town. Affects 34 municipalities in the Greater Copenhagen area	Erhvervsstyrelsen (Danish Business Authority)	https://planinfo.erhvervsstyrelsen.dk/fingerplanen	Public	PDF			Copenhagen	3-6 Years	Ongoing
Development plans for particularly vulnerable public housing area "ghettos plans"	Required demolition rates for the area over the next years (very high demolitions rates) Requirements from retrofit of buildings and new types of buildings (e.g. less public housing)	Trafik-, Bygge- og Boligstyrelsen (The Danish Transport, Construction and Housing Authority)	https://tbst.dk/da/Bolig/Lister/Publikationslisteside?type=Udviklingsplan	Public	PDF		Neighbourhoods	20 appointed neighbourhoods in Denmark		Ongoing
The Copenhagen Map (Københavner kortet)	Interactive maps over development in Copenhagen (major renovations or new buildings), development plans or listed buildings	Copenhagen municipality	https://kbhkort.kk.dk/spatialmap?	Public	PDF		Building block	Copenhagen		Ongoing
Occupation, Building use, Tenure, Ownership, Year of construction	The StatBank Denmark database BOL101 contains information about dwellings in Denmark. Data are available for regions and total for Denmark. Data that can be obtain from the database is: - Occupation - Building use - Tenure - Ownership - Year of construction	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=BOL101&PLanguage=1	Public	Excel		Regional	Denmark	1st January	Ongoing
BBR (Danish Building and Dwelling Register) - Property level	BBR is the Danish Building and Dwelling Register. BBR is the main register/database with information about all legal constructed buildings in Denmark. Information registered on property level in BBR can be: - Number of small buildings - Built Area	Udviklings- og Forenklingsstyrelsen (The Ministry of Taxation)	Property data: https://boligejer.dk/ https://www.ois.dk/ National data: https://datafordeler.dk/	Open on property level; National data requires payment	PDF or raw data	Multiple	Apartment	All buildings	Every day	Ongoing

Opendata.dk	Different dataset from Copenhagen municipality. Currently 288 datasets available	Copenhagen municipality	https://www.opendata.dk/city-of-copenhagen	Open	PDF, CSV, GeoJSON, SHP, XLSX, dwg, DOCX, DWG					
Areas of Regions and Municipalities in Denmark	Database ARE207: Area 1. January by all regions in Denmark - Total area cover of municipalities	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=ARE207&PLanguage=1	Public	Excel	km2	Municipality	Denmark	2007 - present; 1st January	Ongoing
Areas of old Regions and Municipalities in Denmark - Old	Database ARE2: Area by region (DISCONTINUED) - Total area cover of municipalities	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=ARE2&PLanguage=1	Public	Excel	km2	Municipality	Denmark	1985-2006; 1st January	Inactive
Land cover	Database AREALDK: Land by land cover, region and unit - roads - railways - buildings - agricultura - parks - forest - lakes	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=AREALDK&PLanguage=1	Public	Excel	km2 m2 per capita %	Municipality	Denmark	2011, 2016, 2018	Ongoing
Land cover Old	Database ARE1: Land Cover by land cover and unit (DISCONTINUED	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=AREALDK&PLanguage=1	Public	Excel	km2 %	Municipality	Denmark	1995 only	Inactive
Land use by industry	Database AREALAN1: Land use by industry (19a2-grouping), region and unit - Households - Construction - Infrastructure	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=AREALAN1&PLanguage=1	Public	Excel	km2 m2 per capita %	Municipality	Denmark	2016 only	Ongoing

HAMBURG DATA SOURCES - LAND USE										
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**	**Format**	**Units**	**Smallest geography**	**Volume of data**	**Time range & frequency of data collection**	**Ongoing/ Inactive/ Not yet active**
Hamburg Development Database	Development plans (binding construction plans) are legally binding plans, which include building plans, sub-development plans, implementation plans and since 1962 the current development plans according to the Federal Construction Act (BBauG) or from 1986 to the Building Code (BauGB). The zoning plans consist of the plan drawing, the text of the law or regulation with the textual stipulations as well as a justification. Development plans make the binding stipulations for the construction and other use of the land for smaller areas. They have to be developed from the land use plan (preparatory building master plan). *Notes* : The raster data in the form of scanned plans are made available as PDF files via the city and landscape portal (link address see under References). The textual definitions are assigned to the image files in the form of text documents (pdf files). The reasons are also available there as PDF files.	Information about the individual development plans is given by the relevant district office.	https://metaver.de/trefferanzeige?docuuid=EBA4BF12-3ED2-4305-9B67-8E689FE8C445	Public			Borough		All established development plans are presented	Ongoing
Land use / Inspire HH / A III/4 FNP	In the land use plan, the type of land use resulting from the intended urban development is presented according to the foreseeable needs of the City of Hamburg (Baugesetzbuch § 5). It is binding for authorities and public bodies, but does not yet justify any building claims. As a preparatory land-use plan with a scale of 1:20,000, it presents the planning in its basic features. It thus leaves scope for the development plans to be developed from it. A large number of plans and other usage regulations according to other legal regulations are part of the land use plan, for the sake of clarity they are summarized in a separate supplement "Informational transfers, markings and notes". New planning objectives of the City of Hamburg, such as "HafenCity", as well as small-scale changes make constant updating of the land use plan necessary. In addition to the land use plan, the landscape programme is an ecological and open space planning contribution to urban development planning, with emphasis on the qualities of the landscape.		https://metaver.de/trefferanzeige?docuuid=DFDA2969-A041-433B-BD65-4CDA9F830A55	Public			Neighbourhood		Hamburg land use plan as amended by the new announcement of October 1997 including the 1st - 166th amendment and the 1st - 13th correction - as of June 2019	Ongoing

Land Use Register / INSPIRE HH / A III-4 LU	This data set represents the digital planning data of the development plans of the Free and Hanseatic City of Hamburg in the INSPIRE target model. The data were transformed from the XPlanung object model into the Planned Land Use (PLU) GML application schema. Bebauungspläne (binding urban land-use plans) are legally binding plans, which include construction stage plans, partial development plans, implementation plans and, since 1962, today's development plans according to the Federal Building Act (BBauG) and, since 1986, according to the Building Code (BauGB). The development plans consist of the plan drawing, the text of the law or ordinance with the textual stipulations and a justification. For smaller areas, development plans lay down the binding regulations for development and other use of the land. They are to be developed from the land-use plan (preparatory land-use plan).		https://metaver.de/trefferanzeige?docuuid=D059011F-EDBD-4810-9307-BA8D227B5008	Public			Neighbourhood		Weekly	Ongoing
Potential Land Use Database	Selected potential building sites on which at least 20 new residential units could be built in the coming years. For data protection reasons, the underlying geodata are not published.		https://metaver.de/trefferanzeige?docuuid=8223B7BD-D194-4230-B436-1607D3BF3BC5	Public			Point location		Issued 7/2013 last change 6/2016	Inactive
Land register Hamburg	The land register is used by the Free and Hanseatic City of Hamburg as proof of all state-owned land and land rights. Landowner's property is also listed in the directory if it is left to third parties due to real property rights (leasehold rights, etc.) or compulsory (rental or lease agreements, etc.). The register is divided into General Real Estate, Administrative (e.g., Roads) and Special Funds (e.g. School Properties).	immobilienmanagement@lig.hamburg.de	https://metaver.de/trefferanzeige?docuuid=38575F13-7FA2-4F26-973F-EDED24D937E5	Public			Point location		02.02.2015 - 05.11.2015; Everyday	Inactive
Ground reference information	The interactive soil guideline map of Hamburg presents soil guideline values for the entire Hamburg urban area. You can view standard ground values for all available reference dates. Up to and including 2008, typical soil guideline values are available, from 2010 to 2018 zonal soil guideline values will be available. A conversion to the individual plot conditions (plot size or value-relevant number of storeys) is easily possible.		http://www.geoportal-hamburg.de/boris/#	Public			Point location		1964-2018	Ongoing

HELSINKI DATA SOURCES - LAND USE										
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**	**Format**	**Units**	**Smallest geography**	**Volume of data**	**Time range & frequency of data collection**	**Ongoing/ Inactive/ Not yet active**
CORINE-land cover data (SYKE)	Land-use and land cover data. Built area, forest land, agricultural land, mires, water areas, divided in subclasses. E.g. residental area (densely / scarcely populated), industry area, traffic related areas, landfills, land axtraction sites.	Finnish Environment Institute	https://www.syke.fi/fi-FI/Avoin_tieto/Paikkatietoaineistot	Open data			Area/ point location	Map data, raster, national	2000, 2006, 2012, 2018	
Municipal basic maps	Real estates, structures, buildings, road network, land cover, water areas, elevations, on-ground pipelines / gables	Municipality		Public/Open data				municipal	Varies between municipalities	Ongoing
HSY's Regional Land Cover Dataset	Very detailed land cover data including streets, buildings, vegetation (altogether 14 sub-classes), covering Helsinki Metropolitan Area. Based on orthoimages, point clouds and city GIS data	Helsinki Region Environmental Services Authority HSY	https://www.hsy.fi/fi/asiantuntijalle/avoindata/Sivut/AvoinData.aspx?dataID=38	Open data			10 m2	GIS data, vector and raster	Every 2 years	ongoing
Topographic Database	Dataset depicting the terrain of all of Finland. For example, place names, roads, buildings and constructions, other land use, waterways, topographic features and elevations as well as administrative boundaries.	National Land Survey of Finland (NLS)	https://www.maanmittauslaitos.fi/en/maps-and-spatial-data/expert-users/topographic-data-and-how-acquire-it	Open data			Area/ point location	Map data, vector format, national	Continuous	Ongoing
NLS Aerial photographs	Photographs of the terrain taken from an aeroplane. The images are vertical photographs applicable to be used in mapping. The aerial photographs are reprocessed into dimensionally accurate images called orthophotos.	National Land Survey of Finland (NLS)	https://www.maanmittauslaitos.fi/en/maps-and-spatial-data/expert-users/topographic-data-and-how-acquire-it	Open data			Area	National	3 -10 years, depending on the area	Ongoing

LONDON DATA SOURCES - LAND USE										
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**	**Format**	**Units**	**Smallest geography**	**Volume of data**	**Time range & frequency of data collection**	**Ongoing/ Inactive/ Not yet active**
London Development Database	The London Development Database records significant planning permissions in London, including: • Any new build residential units •Any loss or gain of residential units through change of use or conversion of existing dwellings •Creation of seven or more new bedrooms for use as either a hotel, a hostel, student housing or for residential care through new build or change of use •1,000m2 or more of floor space changing from one use class to another or created through new build or extension for any other use •The loss or gain or change of use of open space. The LDD provides data on number of planning permission cases that are completed, started and not yet started, and gives precise information on location. Where SWMPs have been submitted, these will provide a precise idea of waste arisings and routes. NB City Hall is not responsible for adding any information to the database (this is done by local authorities), or for the quality or completeness of data. Also see article for information on data quality. See also the LDD Automation Project, which intends to be a 'live hub' of publicly accessible data and information on planning and development, hoped to be implemented in 2020. Achieved by requesting the data required for monitoring up-front on the initial planning application. This could be a highly valuable source of data, e.g. by allowing access to Waste Management Plans. Additionally, new planning policy may require further information related to circular construction, e.g. use of reclaimed materials.	Greater London Authority (GLA) - Peter Kemp	https://data.london.gov.uk/dataset/planning-permissions-on-the-london-development-database--ldd-	Open	XLS	Qualitative description	Postcode & point location	70621 cases at time of access	01.04.06 – present; Monthly (permissions) Annually (starts and completes)	Ongoing

London Planning Data Map	Project to collate and share spatial planning data for the whole of London. The aim is to create a single map that can become the definitive source for London's planning data, providing site-specific information on planning designations. Contains data on: • Brownfield Registers • Site Allocations • Opportunity Areas • Town Centres • Areas of Intensification • Central Activities Zone • SHLAA approvals and allocations • Designated Open Space • Site of Importance for Nature Conservation • Sites of Special Scientific Interest • Flood Risk • Conservation Areas • Strategic Industrial Locations • Locally Significant Industrial Sites • Safeguarded Wharves • Article 4 Directions: Office to Residential • Protected vistas • Housing Zones • Creative Enterprise Zones All data will be available for download by the public.	Greater London Authority (GLA)	https://maps.london.gov.uk/planning/	N/A	Map	Polygons	Point location	N/A	Unknown	Ongoing
Plot Ratios in Industrial Developments	Lists all planning permissions granted to industrial developments between 1/4/11 and 28/2/18 (completed, lapsed, started, not yet started, and superseded). Provides info on plot area ratio (gross floor area of all floors of a building divided by area of the building lot), total floorspace of built site, maximum # of storeys (in some cases), proposed area of residential and non-residential site, existing area of greenfield land, proposed open space and site area, existing and proposed # of residential units, existing and proposed # bedrooms, and various others.	GLA	https://data.london.gov.uk/dataset/plot-ratios-in-industrial-developments-april-2011---february-2018	Open	Excel	Multiple	Individual property; Point location	401 records	2011-2018	Inactive

OS AddressBase (basic, pro, premium)	Basic AddressBase has csv data on Royal Mail postal addresses, where matched to a UPRN and coordinates for each address. AddressBase Plus has the above plus Local authority Bs7666 addresses, objects without postal addresses, addresses with multiple occupants, OS MasterMap Topography Layer and Integrated Transport Network TOIDs, and the associated alternative record. AddressBase Premium has the above plus Pre-build addresses, historic addresses, and, alternative addresses.	Ordnance Survey	*Basic :* https://www.ordnancesurvey.co.uk/business-government/products/addressbase *Plus:* https://www.ordnancesurvey.co.uk/business-government/products/addressbase-plus *Premium:* https://www.ordnancesurvey.co.uk/business-government/products/addressbase-premium	License needed for all types	CSV	Multiple	Individual property; Point location	Every UK address	Unknown; Every 6 weeks	Ongoing
Generalised Land Use Database (GLUD)	Land Use Statistics by ward as of 2005 using GLUD. Uses include area (and % of total area) covered by domestic buildings, gardens, non-domestic buildings, greenspace, paths, rail, road and water.	MHCLG	https://data.london.gov.uk/dataset/land-use-ward	Open	CSV, XLS	000's m2 %	Ward	~620	2005 only	Inactive
National Polygon Service	Dataset shows the indicative shape and position of each boundary of a registered title for land and/or property in England and Wales. Every title, whether freehold or leasehold, has at least one index polygon. Data includes: - shape - polygon identification - title number - date when polygon was created - update date (date when all or part of the title was last updated) - version of polygon identification number - record status (indicates aditions, changes and deletions to the records)	HM Land Registry	https://www.gov.uk/guidance/national-polygon-service#national-polygon-dataset	Paid	CSV	Multiple	Point location	>25 million	Unknown - 2016	Unknown

Historic Landscape Characterisation	Database of land use polygons. For each polygon, database record is typically divided into several tabs: Description, Attributes, Previous Type(s), Monuments, Sources. See URL for full description of the types of information provided under these tabs. There is a specific type of HLC for urban areas, the Metropolitan HLC. NB there doesn't appear to be a publicly available HLC for London. In cases where it has not been made publicly available, an HLC is usually held by a local Historic Environment Record, but in a London HER report it states that they only have a partial HLC. The HLC database was used in the REBUILD project to estimate and map the stocks of bricks in Bradford, UK.	Historic England	https://historicengland.org.uk/research/methods/characterisation-2/historic-landscape-characterisation/#Section2Text	Not open	Unknown	Polygons	Individual property; Point location	Unknown	Unknown	Ongoing
Brownfield Land Register	The Town and Country Planning (Brownfield Land Register) Regulations 2017 requires local authorities to prepare and maintain registers of previously developed (brownfield) land that is suitable for residential development. GLA-held register of brownfield sites contains information on permissions given and descriptions of planned development, often with links to further info on planned works on planning authority website. NB local planning authorities are encouraged but not mandated to keep the GLA register up-to-date, and so the database/map may not display all brownfield planning cases may not appear.	Held by GLA but data collected by individual LAs	https://data.london.gov.uk/dataset/brownfield-land-register For example, see City of London website: cityoflondon.gov.uk/services/environment-and-planning/planning/development-and-population-information/Pages/development.aspx	Open	CSV, Shapefile	Multiple	Postcode / point location	2491 cases, multiple entries each	2003-2019; Annual	Ongoing
Land Use - Previously Developed Land, Borough	Estimates of the amount of previously developed (or brownfield) land which may be available for re-development, and also an estimate of the potential number of dwellings that could be provided on this land. Provides info on amount of vacant land, vacant buildings, estimated number of dwellings possible for construction on vacant land, planning permission status of land, etc.	MHCLG	https://data.london.gov.uk/dataset/land-use-previously-developed-land-borough	Open	XLS	Multiple	Borough	~5500	2004-2010; Annual	Inactive
Site Allocations	Allocation for a particular type of development or use, such as housing, employment and leisure, within a development plan. Allocated sites provide guidelines for planning decisions, help to diversify use of land and promote development at borough level. Available on GLA planning data map, as a GIS dataset, and as an API.	GLA	https://data.london.gov.uk/dataset/site_allocations	Open	HTML, geopackage	Custom polygons	Point location	Unknown	Time range unknown; Ad-hoc collection	Ongoing
GLA Group Land Assets	Datasets showing the location of land and property holdings of GLA, London Fire Brigade, London Legacy Development Corporation, Met Police Service and TfL, plus development opportunities.	GLA	https://data.london.gov.uk/dataset/gla-group-land-assets	Open	CSV	Multiple	Point location / postcode	Varies (multiple datasets available)	2018 only	Unknown

Strategic Housing Land Availability Assessment	Database of quantity and suitability of land potentially available for housing development across London. Provides info on gross site area, identified housing capacity, and start/completion years.	GLA	https://data.london.gov.uk/dataset/shlaa-2017-approvals-allocations	Open (on condition of attribution)	XLS, Shapefile	Multiple, qualitative and quantitative	Point location	Varies (multiple datasets available)	2017 - 2041	Inactive
Borough development/local plans and area action plans/neighbourhood plans	Planning frameworks and policies that set out future development (usually 15-20 years?) for boroughs as a whole (in the case of development/local plans), as well as at a more granular level for neighbourhoods and other significant areas earmarked for development within boroughs (in the case of area action plans/neighbourhood plans), such as town centres. Available for each borough (see e.g. Camden Local Plan; Old Oak and Park Royal Development Corporation Local Plan), with area action plans and neighbourhood plans developed for specific locations (e.g. Old Kent Road Area Action Plan). These provide estimates for the scale and locations of development, as well as the types of development. NB these must be in general conformity with the London Plan and must be consistent with the NPPF and NPPG.	Local authorities	Various locations	Varies	Report	n/a	n/a	n/a	Varies	Ongoing

COPENHAGEN DATA SOURCES - MATERIAL STOCKS AND FLOWS										
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**	**Format**	**Units**	**Smallest geography**	**Volume of data**	**Time range & frequency of data collection**	**Ongoing/ Inactive/ Not yet active**
Extraction of raw materials in Denmark by region or municipality	Database RST01: Extraction of raw materials in Denmark by region and type of raw material - Total extraction from land - Stone, gravel and sand - Quartz sand - Granite - Clay - Plastic clay and bentonite - Moler - Chalk and Limestone - Peat and sphagnum - Other raw materials	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=RST01&PLanguage=1	Public	Excel	1000 m3	Municipality	Denmark	2006-2018, Annual	Ongoing
Extraction of raw materials in Denmark by municipality - old	Database RST: Extraction of raw materials in Denmark by minicipality and different types of raw material (DISCONTINUED) - Total extraction from land - Stone, gravel and sand - Quartz sand - Granite - Clay - Plastic clay and bentonite - Moler - Chalk and Limestone - Peat and sphagnum - Other raw materials	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=RST&PLanguage=1	Public	Excel	1000 m3	Municipality	Denmark	1989-2006, Annual	Inactive
Extraction of raw materials from ocean in Denmark	Database RST3: Extraction of raw materials in Denmark - Total extraction from sea floor - Sand - Gravel and stone - Gravel - Paddings - Stones - Shells	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=RST3&PLanguage=1	Public	Excel	1000 m3	Sea or belt	Denmark	1990-2018, Annual	Ongoing
Unloading of raw materials	Database RST04: Unloading of raw materials from the bottom of the sea by region and type of raw material - Total extraction from sea floor - Sand - Gravel and stone - Gravel - Paddings - Stones - Shells	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=RST04&PLanguage=1	Public	Excel	1000 m3	Municipality	Denmark	2007-2018, Yearly	Ongoing

Economy-wide material flow	Database MRM2: Economy-wide material flow accounts by material type and indicator - Domestic extraction - Import - Direct Material Input - Export - Domestic Material Consumption - Physical Trade Balance	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=MRM2&PLanguage=1	Public	Excel	Ton	Denmark	Denmark	Since 1993, Yearly	Ongoing
Number of buildings with different roof materials	The StatBank Denmark database BYGB50 contains information about number of buildings with different roofing materials. The data can be sorted by region, building use, year of construction.	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=BYGB50&PLanguage=1	Public	Excel	Number or m2	Regional	Denmark	2011 - present, 1st January	Ongoing
Number of buildings with different Wall materials	The StatBank Denmark database BYGB60 contains information about number of buildings with different outer wall materials. The Data can be sorted by region, building use, year of construction.	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=BYGB60&PLanguage=1	Public	Excel	Number or m2	Regional	Denmark	2011 - present, 1st January	Ongoing
Energy consumption of industry by municipality	Database ENEGEO: Energy consumption of industry by municipality	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=ENEGEO&PLanguage=1	Public	Excel	1000 GJ	Municipality	Denmark	2012-2018, Every second year	Ongoing
Electricity prices for households	Database ENERGI1: Prices of electricity for households by annual consumption, price definition and energy unit	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=ENERGI1&PLanguage=1	Public	Excel	DKK per unit (kWh or GJ)	Denmark	Denmark	2015-2019, half year	Ongoing
Electricity prices for industry	Database ENERGI2: Prices of electricity for non-households by annual consumption, price definition and energy unit	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=ENERGI2&PLanguage=1	Public	Excel	DKK per unit (kWh or GJ)	Denmark	Denmark	2015-2019, half year	Ongoing
Natural gas prices for households	Database ENERGI3: Prices of natural gas for households by annual consumption, price definition and energy unit	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=ENERGI3&PLanguage=1	Public	Excel	DKK per unit (m3 or GJ)	Denmark	Denmark	2015-2019, half year	Ongoing
Natural gas prices for industry	Database ENERGI4: Prices of natural gas for non-households by annual consumption, price definition and energy unit	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=ENERGI4&PLanguage=1	Public	Excel	DKK per unit (m3 or GJ)	Denmark	Denmark	2015-2019, half year	Ongoing
Air emissions from industry in Denmark	Database EMM1MU3: Air emissions caused by final demand, by industry and type of emission	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=EMM1MU3&PLanguage=1	Public	Excel	CO2, SO2, NOX, CO, NH3, N2O, CH4, NMVOC	Denmark	Denmark	1990-2018, Annual	Ongoing

Direct and indirect air emissions from households	Database EMM1MU2: Direct and indirect air emissions by final demand and type of emission	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=EMM1MU2&PLanguage=1	Public	Excel	CO2, SO2, NOX, CO, NH3, N2O, CH4, NMVOC	Denmark	Denmark	1990-2018, Annual	Ongoing
Direct and indirect air emissions by building industry	Database EMM1MU1: Direct and indirect air emissions by industry and type of emission	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=EMM1MU1&PLanguage=1	Public	Excel	CO2, SO2, NOX, CO, NH3, N2O, CH4, NMVOC	Denmark	Denmark	1990-2018, Annual	Ongoing
Manufacturers purchase of goods	Database RP03: Manufacturers purchase of goods (per cent of turnover) by industry (DB07) and level of processing - Raw products - Semi-finished products - Finished products - All products - Manufacture of plastic, glass and concrete	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=RP03&PLanguage=1	Public	Excel	percent	Denmark	Denmark	2001-2017, Annual	Ongoing
Environmental Product Declaration (EPD)	International database for material EPD's	The International EPD System	https://www.environdec.com/EPD-Search/	Public	PDF		Product	World		Ongoing

HAMBURG DATA SOURCES - MATERIAL STOCKS AND FLOWS										
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**	**Format**	**Units**	**Smallest geography**	**Volume of data**	**Time range & frequency of data collection**	**Ongoing/ Inactive/ Not yet active**

HELSINKI DATA SOURCES - MATERIAL STOCKS AND FLOWS										
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**	**Format**	**Units**	**Smallest geography**	**Volume of data**	**Time range & frequency of data collection**	**Ongoing/ Inactive/ Not yet active**
Regional Base Register (SePe)	Main building construction material of bearing structures (concrete or lightweight concrete, brick, steel, wood, other). Information is mainly comprehensive in buildings that are completed after 1983	Helsinki Region Environmental Services Authority HSY	https://www.hsy.fi/en/experts/regional-data/geographic-information/Pages/SePe.aspx	Partly public, only for municipalities			Area and point location	Helsinki Metropolitan Area (Helsinki, Espoo, Vantaa, Kauniainen)	Every 2 weeks	Ongoing

Volume index of industrial output	The volume index of industrial output describes the relative change in the volume of industrial output at fixed prices when compared with a specific base period. Original index, index adjusted for working days, seasonally adjusted index and trend. Value of sold production (€) and amount (t/kg/m2) of 2000 PRODCOM items, total amount of production of 230 items (t/kg/m2). 38 fields of industry.	Statistics Finland	http://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin_Passiivi/StatFin_Passiivi__teo__ttvi/statfinpas_ttvi_pxt_001_201712.px/	Open data			National	National data	Monthly	Ongoing
Statistics of foreign trade	Value of import and export of products on 23 different fields of industry. Value and amounts of import and export divided in 4 different classification of goods (CN, SITC, CPA, BEC). Values and type of products also according to continent and country.	Customs	https://tulli.fi/en/statistics , http://uljas.tulli.fi/uljas/	Open data				National data	Monthly	Ongoing
Case studies of materials in buildings	Multiple	E.g. Aalto university	Examples: https://aaltodoc.aalto.fi/handle/123456789/13979 https://aaltodoc.aalto.fi/handle/123456789/41384	Public						

LONDON DATA SOURCES - MATERIAL STOCKS AND FLOWS

Title	Description	Source/ contact	URL	Accessibility	Format	Units	Smallest geography	Volume of data	Time range & frequency of data collection	Ongoing/ Inactive/ Not yet active
MPA Cement: Sustainable Development Report 2019	Information from 2010-2018 on: Impacts on natural environment Total waste and by-products used as fuel and raw materials in cement production Proportion of raw material comprising waste Proportion of fuel comprising waste material Biomass fraction of fuel input Process waste recovered onsite Process waste recovered offsite Process waste sent to landfill Locations of kiln sites, grinding sites and blending sites. Stats are at national level (other than locations of kilns etc) Does not state how stats and figures were obtained.	Mineral Products Association	https://mineralproducts.org/sustainability/reports.html	Figures & stats publicly visible; underlying data not found	Report	Various	National	Low (though the underlying data for the analyses will be larger)	2010 - 2018; Annual (assumed based on graphs showing annual figures)	Ongoing
British Lime Association: Sustainable Development Report 2019	Information from 2010-2018 on: Impacts on natural environment Waste sent to landfill for all lime manufacturing Proportion of alternative fuels in dolime manufacture Locations of BLA members Stats are at national level (other than locations of kilns etc) Does not state how stats and figures were obtained.	Mineral Products Association	https://mineralproducts.org/sustainability/reports.html	Figures & stats publicly visible; underlying data not found	Report	Various	national	Low (though the underlying data for the analyses will be larger)	2011 - 2018; Annual (assumed based on graphs showing annual figures)	Ongoing

Monthly Bulletin of Building Materials and Components	Provides information on selected building materials and contains monthly data on price indices, bricks, cement and concrete blocks; and quarterly data on sand and gravel, slate, concrete roofing tiles and ready-mixed concrete. Clearly leaves off some high-volume construction materials e.g. steel, gypsum, insulation, plus all construction products, so does not provide full account of material consumption in the construction sector. NB only sand and gravel is reported to the level of county (and therefore specific to London alone).	BEIS	https://data.gov.uk/dataset/75ee36ed-21f7-4d7b-9e7c-f5bf4546145d/monthly-statistics-of-building-materials-and-components	Open	Report (PDF); Data tables (ODS)	Various	County (sand & gravel) Region (for bricks and concrete building blocks) Country (slate, cement & clinker or concrete roof tiles)	Multiple indices per month, split by category of material	Start data varies; continues to present; Monthly	Ongoing
Trustmark Data Warehouse (not published yet)	Trustmark building Data Warehouse populated with info gathered by installers of ECO3 retrofit scheme installers (large proportion of retrofits will be using this scheme) about work undertaken and the property being improved. One of stated aims of this is to help industry understand the market, and to feed into property passports. Could provide figures on typical material requirements and release plus waste arisings from retrofit projects.	Trustmark	https://www.trustmark.org.uk/ourservices/data-warehouse	Open	Unknown	Various	Postcode	Not yet active	Unknown	Not yet active
UK Minerals Yearbook	British Geologiocal Survey annually gathers data on mineral extraction and trade in the UK. It previously sourced data from ONS datasets (Mineral Extraction in Great Britain), however these are no longer published and their data only goes up to 2014. Currently, the BGS gathers data from alternative sources including the Mineral Products Association and the British Ceramics Confederation, amongst others, though details of data collected are not provided. Data available on the number of mineral workings by region (including Greater London); however all other data is national and non-regional.	British Geological Survey	https://www.bgs.ac.uk/downloads/browse.cfm?sec=12&cat=132	Figures & stats publicly visible; underlying data not found	Report (PDF)	Various	Some regional, most national	Unknown	Up to present; Annual	Ongoing
Builders Merchant Federation Index	The Builders' Merchant Federation releases the Builders' Merchant Building Index (BMBI) on a monthly basis, based on data collected by market research firm GfK's Builders Merchant Panel from over 80% of generalist builders merchants' sales throughout the UK, and the BMF's own Sales Indicators based on monthly returns from the majority of merchant members outlets. Data is available at a regional level and therefore could be useful for building a picture of the amount of construction materials and products entering the city system. Additionally, they release an industry forecast for builders' merchants sales annually.	Builders Merchant Federation	https://www.bmf.org.uk/BMF/InformationCentre/Market_Data/BMF/Information_Centre/MarketData.aspx?hkey=cea9a5e0-acea-445b-9a45-73268721c0f2	Paid; availability for analysis unknown	Unknown	Unknown	Region	Unknown	Unknown; Monthly	Ongoing

Research reports and articles estimating volume and proportion of materials within building stocks	REBUILD Project Stephan and Athanassiadis (2017) - Melbourne study Schebek et al (2017) Non-residential stock in the Rhine-Main area. Oezdemir, Krause and Hafner (2017) Rhine-Ruhr Metropolitan Area		REBUILD							
			Melbourne study:							
			Rhine-Main:							
			Rhine-Ruhr:							
REAP Progress Report 1 (Brick & Concrete; 2017)	Provides some figures on proportions of brick, precast and ready mixed concrete waste landfill, with indications of progress through time. Citations not provided and raw data sources not listed.	Mineral Products Association		Figures & stats publicly visible; underlying data not found						
Brick Development Association Sustainability Report	Annual report on the sustainability of the UK brick industry, with information and statistics on wellbeing, biodiversity and community, water, energy and carbon, waste, circular economy and materials, and continual improvement. Presents figures on waste per tonne production, volume of waste sent to landfill, proportions of CO2 emissions by brick life cycle stage and others.	Brick Development Association		Figures & stats publicly visible; underlying data not found						

COPENHAGEN DATA SOURCES - PROCESSES & STANDARDS				
Title	**Description**	**URL**	**Accessibility**	**Ongoing/ Inactive/ Not yet active**
Standard DS/EN 15978:2012	Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method			
Standard DS/EN 15643 (5 standards)	Sustainability of construction works			
Standard DS/EN 16627	Sustainability of construction works - Assessment of economic performance of buildings - Calculation methods			
Standard DS/EN 15804 2012+A2 2019	Sustainability of construction works – Environmental product declarations			
Mandatory building screening at demolition with PCB	Vejledning om håndtering af bygge- og anlægsaffald (VEJ nr 9139 af 25/02/2019)	https://mst.dk/media/169578/vejledning-om-haandtering-af-bygge-og-anlaegsaffald.pdf		
The Waste Regulation Act	Bekendtgørelse om affald (BEK nr 224 af 08/03/2019)	https://www.retsinformation.dk/Forms/R0710.aspx?id=207367		
The Waste and Raw Materials Tax Act	Affalds- og råstofafgiftsloven (LBK nr 412 af 21/04/2017)	https://www.retsinformation.dk/Forms/R0710.aspx?id=188421		
The Environmental Protection Act	Bekendtgørelse af lov om miljøbeskyttelse (LBK nr 1218 af 25/11/2019)	https://www.retsinformation.dk/Forms/R0710.aspx?id=210726		
The Building Damage Insurance Act	Bekendtgørelse om byggeskadeforsikring (BEK nr 1292 af 24/10/2007)	https://www.retsinformation.dk/Forms/R0710.aspx?id=113467		
The Planning and development Act	Bekendtgørelse af lov om planlægning (LBK nr 287 af 16/04/2018)	https://www.retsinformation.dk/Forms/R0710.aspx?id=200614		
The Building Regulation Act	Bekendtgørelse om bygningsreglement 2018 (BR18) (BEK nr 1399 af 12/12/2019)	https://www.retsinformation.dk/Forms/R0710.aspx?id=211473		
Temporary Regulation of Housing Conditions Act	Bekendtgørelse af lov om midlertidig regulering af boligforholdene (LBK nr 929 af 04/09/2019)	https://www.retsinformation.dk/Forms/R0710.aspx?id=210125		

New sustainability class (DK)	Starts summer 2020. Optional until 2023. After that mandatory	https://ing.dk/artikel/byggeriets-nye-baeredygtighedsklasse-klar-branchen-tripper-ministeren-toever-223777		
Ecodesign (EU)				
HAMBURG DATA SOURCES - PROCESSES & STANDARDS				
Title	**Description**	**URL**	**Accessibility**	**Ongoing/ Inactive/ Not yet active**
HELSINKI DATA SOURCES - PROCESSES & STANDARDS				
Title	**Description**	**URL**	**Accessibility**	**Ongoing/ Inactive/ Not yet active**
Vantaa building regulation	Municipality's own regulations that complement legislational and other general regulations for constructions. Gives more detailed guidelines for building activities on municipalitys area, e.g. location and placement of buildings, materials, appearance, noice control, repairs and replacements, yard, etc. *Notes* : Every municipality has similar regulations with slightly varying contents.	https://www.pksrava.fi/doc/yleiset/rivi_236.pdf	Public	
LONDON DATA SOURCES - PROCESSES & STANDARDS				
Title	**Description**	**URL**	**Accessibility**	**Ongoing/ Inactive/ Not yet active**
ISO 20400 - Guidance for responsible procurement	Provides guidance to organizations, independent of their activity or size, on integrating sustainability within procurement, as described in ISO 26000. It B14is intended for stakeholders involved in, or impacted by, procurement decisions and processes.	https://www.iso.org/standard/63026.html		
Tfl Health, Safety & Environment Reports	Reports on a number of HSE metrics, however there is nothing on material consumption, waste, or embodied carbon.	https://tfl.gov.uk/corporate/publications-and-reports/health-safety-and-environment?intcmp=3077		

COPENHAGEN DATA SOURCES - RATE OF WORKS (Current & future number/rate/extent of construction, retrofit, refurbishment, renovation, & demolition)										
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**	**Format**	**Units**	**Smallest geography**	**Volume of data**	**Time range & frequency of data collection**	**Ongoing/ Inactive/ Not yet active**
Number of new buildings	The StatBank Denmark database BYGV01 contains information about completed and ongoing construction i Denmark. Data that can be obtain from the database is: - Number of started construction - Number of completed construction - Number of buildings under construction - Number of permits - Types of buildings - Builders - Years	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=BYGV01&PLanguage=1	Public	Excel	Period, umber or m2	Denmark	Denmark	1998-2019, Annual	Ongoing
Construction period	The StatBank Denmark database BYGV02 contains information about the completion period for new construction in Denmark. Data that can be obtain from the database is: - Construction period (same-, 1, 2, or 3 years) - Dwellings - Number of new buildings, extensions or conversions - Total floor area (m2) - Types of buildings - Years	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=BYGV02&PLanguage=1	Public	Excel	Period, umber or m2	Denmark	Denmark	1998-2019, Annual	Ongoing
Cost of services and products	Database RP05: Costs by cost element, industry and price unit - Construction of new buildings - Civil engeneering - Professionel Repair and maintenance of buildings - Own-account Repair and maintenance of buildings	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=RP05&PLanguage=1	Public	Excel	million DKK	Denmark	Denmark	2005-2018, Annual	Ongoing
Index of production in Construction	Database BYGPRO: Index of production in Construction (IPC) (2015=100) by industry - Total - Construction - Civilengineering	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=BYGPRO&PLanguage=1	Public	Excel	million DKK	Denmark	Denmark	2000 - present. Monthly	Ongoing
Demolitions and renovations reportet to the Copenhagen municipality	Notification of building waste to the municipality of Copenhagen. Upon notification, the buildingowner must indicate whether the waste originates from demolition or renovation, together with the address and floor area of the building. Notification to the municipalities are required if: The building or renovated room is more than 10 m2 The construction project creates more than 1 ton of waste If the waste contains windows manufactured in the period 1950-1977 If the building is from before 1977, the notification must be supplemented with a mapping for PCBs and other environmentally hazardous substances	Copenhagen municipality	bygningsaffald.dk	Private	No information		Building		No information	Ongoing

Demolitions reportet to BBR	Date of demolition of building	Udviklings- og Forenklingsstyrelsen (The Ministry of Taxation)	Property data: https://boligejer.dk/ https://www.ois.dk/ National data: https://datafordeler.dk/	Public open on property level National data require payment	PDF or raw data	Multiple	Apartment	All buildings	Old, Everyday	Ongoing

HAMBURG DATA SOURCES - RATE OF WORKS (Current & future number/rate/extent of construction, retrofit, refurbishment, renovation, & demolition)

Title	Description	Source/ contact	URL	Accessibility	Format	Units	Smallest geography	Volume of data	Time range & frequency of data collection	Ongoing/ Inactive/ Not yet active
Number of dwellings and net additional dwellings	Apartments by type of building and type of use	Source: Statistics Office North	https://www.hamburg.de/wohnungsbestand-in-hamburg/	Public			City wide		2011/12	Inactive
Report - Housing and Urban development	Report on the major Hamburg urban development projects and Senate opinion on the request of the citizenship of December 15, 2016: "We create modern Hamburg: housing, tenant protection, urban development - Continue successful urban development policy in the sense of a socially fair, liveable and affordable metropolis! : Housing construction and housing promotion continue at a high level in the longer term "Drucksache 21/7012		http://www.buergerschaft-hh.de/parldok/tcl/PDDocView.tcl?mode=get&lp=21&doknum=18216	Public			Neighbourhood		03.09.2019	Inactive
City-level planning applications and decisions	Selected completed housing projects are presented with a short description and a picture. The information is also linked to a project page on hamburg.de.		https://metaver.de/trefferanzeige?docuuid=2E74D411-814C-4E65-9C9F-861517B5F393	Public			Point location		2014	Inactive
Borough development/local plans and area action plans/neighbourhood plans	The aim of the map "Cooperation projects with neighbouring communities and districts in Hamburg" is to communicate projects and activities for cross-border cooperation. The interactive map uses various symbols to represent cooperation projects between Hamburg and its neighbouring municipalities and districts in which the Hamburg Ministry of Urban Development and Environment or a Hamburg district is involved. The map is limited to three zoom levels. Each project shown is assigned to one of seven categories, each represented by a symbol: Development concepts, neighbourhood forum, regional park, urban development project, nature conservation project, transport project, regional workshop. By clicking on a symbol, the user receives brief information about the concrete project, the Hamburg contact and, if applicable, the corresponding link to the project page. The map is continuously updated by the Department of Urban Development and Environment (Department of Regional Planning and Regional Development).		https://metaver.de/trefferanzeige?docuuid=C8BC68C7-EA57-4147-AC23-BC41E0A2DC80	Public			Borough		last actualisation 05/2012	Inactive

Number of vacant dwellings	Statista Research Department, Vacancy rate of apartments in Hamburg from 2001 to 2017		https://de.statista.com/statistik/daten/studie/252750/umfrage/leerstandsquote-von-wohnungen-in-hamburg/	Public, account needed to view & download			City wide		2001-2018	Inactive
HELSINKI DATA SOURCES - RATE OF WORKS (Current & future number/rate/extent of construction, retrofit, refurbishment, renovation, & demolition)										
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**	**Format**	**Units**	**Smallest geography**	**Volume of data**	**Time range & frequency of data collection**	**Ongoing/ Inactive/ Not yet active**
LONDON DATA SOURCES - RATE OF WORKS (Current & future number/rate/extent of construction, retrofit, refurbishment, renovation, & demolition)										
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**	**Format**	**Units**	**Smallest geography**	**Volume of data**	**Time range & frequency of data collection**	**Ongoing/ Inactive/ Not yet active**
London Development Database	The London Development Database records significant planning permissions in London, including: • Any new build residential units • Any loss or gain of residential units through change of use or conversion of existing dwellings • Creation of seven or more new bedrooms for use as either a hotel, a hostel, student housing or for residential care through new build or change of use • 1,000m2 or more of floor space changing from one use class to another or created through new build or extension for any other use • The loss or gain or change of use of open space. The LDD provides data on number of planning permission cases that are completed, started and not yet started, and gives precise information on location. Where SWMPs have been submitted, these will provide a precise idea of waste arisings and routes. NB City Hall is not responsible for adding any information to the database (this is done by local authorities), or for the quality or completeness of data. Also see article for information on data quality. See also the LDD Automation Project, which intends to be a 'live hub' of publicly accessible data and information on planning and development, hoped to be implemented in 2020. Achieved by requesting the data required for monitoring up-front on the initial planning application. This could be a highly valuable source of data, e.g. by allowing access to Waste Management Plans. Additionally, new planning policy may require further information related to circular construction, e.g. use of reclaimed materials.	Greater London Authority (GLA)	https://data.london.gov.uk/dataset/planning-permissions-on-the-london-development-database--ldd-	Open	XLS	Qualitative description	Postcode & point location	70621 listings at time of access (December 2019)	01.04.06 – present; Monthly (permissions) Annually (starts and completes)	Ongoing

London Planning Data Map	Project to collate and share spatial planning data for the whole of London. The aim is to create a single map that can become the definitive source for London's planning data, providing site-specific information on planning designations. Contains data on: • Brownfield Registers • Site Allocations • Opportunity Areas • Town Centres • Areas of Intensification • Central Activities Zone • SHLAA approvals and allocations • Designated Open Space • Site of Importance for Nature Conservation • Sites of Special Scientific Interest • Flood Risk • Conservation Areas • Strategic Industrial Locations • Locally Significant Industrial Sites • Safeguarded Wharves • Article 4 Directions: Office to Residential • Protected vistas • Housing Zones • Creative Enterprise Zones All data will be available for download by the public.	Greater London Authority (GLA)	https://maps.london.gov.uk/planning/	N/A	Map	Polygons	Point location	N/A	Unknown	Ongoing
London Plan AMR planning data - housing	To check performance against the KPIs of the London Plan, an Annual Monitoring Report is compiled with relevant data, including: •Number of housing approvals for year passed •Number of housing starts for year passed •Number of housing completions for year passed •Housing pipeline For each entry, information is provided on (existing and, where relevant, proposed) number of residential units, floorspace, number of bedrooms, and site area. Data is drawn from the London Development Database (see row above).	GLA	https://data.london.gov.uk/dataset/london-plan-amr14-tables-and-data	Open	Excel	Multiple	Postcode & point location	Varies (multiple datasets available)	2016 - present; Annual	Ongoing
Number of dwellings and net additional dwellings	Displays net additions to housing stock by borough and for London, other regions, and England as a whole. Also displays total dwelling numbers and # persons per dwelling. Merton-specific data features on Merton website. Appears that Merton gets their public data from MHCLG, the VOA etc.	MHCLG	https://data.london.gov.uk/dataset/net-additional-dwellings-borough	Open	Excel	#	Borough		2004 – present (net additions) 2001 – present (all dwellings) Updated annually	Ongoing
Live tables on house building: new build dwellings	Provides numbers of dwellings completed down to borough level per quarter. See table 253a	MHCLG	https://www.gov.uk/government/statistical-data-sets/live-tables-on-house-building	Open	CSV	#	Borough	~3500 per quarter	2010 - present; Quarterly	Ongoing

OS AddressBase (basic, pro, premium)	Analysis of changes in total built volume for a given area, as well as information on typology splits (where available) and material composition of typologies (where available) could be used to calculate total material additions and release for that area. OS and HLC data were used in REBUILD project to estimate building stock change through time. See 'building stock' category for descriptions of these datasets.	Ordnance Survey	Basic : https://www.ordnancesurvey.co.uk/business-government/products/addressbase Plus: https://www.ordnancesurvey.co.uk/business-government/products/addressbase-plus Premium: https://www.ordnancesurvey.co.uk/business-government/products/addressbase-premium	License needed for all types	CSV	Multiple	Individual property; Point location	Every UK address	Unknown; Every 6 weeks	Ongoing
OS Building Height Attribute		Ordance Survey	https://www.ordnancesurvey.co.uk/business-government/products/mastermap-building	License required	CSV	Multiple	Individual property; Point location	Every UK building	Unknown	Ongoing
Historic Landscape Characterisation		Historic England	https://historicengland.org.uk/research/methods/characterisation-2/historic-landscape-characterisation/#Section2Text	Not open	Unknown	Polygons	Individual property; Point location	Unknown	Unknown	Ongoing
Borough-level planning applications and decisions	Planning applications and decisions are generally searchable on local authority websites as weekly and monthly lists, providing information on the construction and development pipeline, and potentially on resource sources and sinks. NB the London Development Database is bringing all of these together into a single centralised database, however it is inclear whether there is additional data available.	Local Authorities (LAs)	Various	Varies	Unknown	Unknown	Varies ; unknown	Unknown	Start date varies –> now usually updated weekly/monthly	Ongoing

Borough development/local plans and area action plans/neighbourhood plans	Planning frameworks and policies that set out future development (usually 15-20 years?) for boroughs as a whole (in the case of development/local plans), as well as at a more granular level for neighbourhoods and other significant areas earmarked for development within boroughs (in the case of area action plans/neighbourhood plans), such as town centres. Available for each borough (see e.g. Camden Local Plan; Old Oak and Park Royal Development Corporation Local Plan), with area action plans and neighbourhood plans developed for specific locations (e.g. Old Kent Road Area Action Plan). These provide estimates for the scale and locations of development, as well as the types of development. NB these must be in general conformity with the London Plan and must be consistent with the NPPF and NPPG.	Local authorities	Various	Varies	Unknown	Unknown	Varies ; unknown	Unknown	Varies	Ongoing
Potential Strategic Importance planning applications and decisions	Planning applications of Potential Strategic Importance (generally large buildings and developments) are referred by local authorities to the Mayor for decision or referral back to the LA. Information on the status of the application and decision is provided. Often includes fairly detailed qualitative information on works to be undertaken. NB this data shows applications, not decisions.	GLA	https://www.london.gov.uk/what-we-do/planning/planning-applications-and-decisions/current-planning-applications	Open	XLSX	Qualitative description	Point location	>10,000	2016 - present; Weekly	Ongoing
Number of vacant dwellings	The data provide information on vacant dwellings, by period vacant and second homes, and were produced from Local Authority (LA) Council Tax systems.	MHCLG	https://data.london.gov.uk/dataset/vacant-dwellings?resource=c428a18b-9961-4b98-9cfe-b7f120114141	Open	XLS	#	Borough	~2800	2004 – 2019; Annual	Ongoing
Commercial and industrial property vacancy statistics	Estimated vacancy rates by percentage, for commercial and industrial properties.	MHCLG	https://data.london.gov.uk/dataset/commercial-and-industrial-property-vacancy-statistics-borough?resource=f2a94f0f-5ac6-40a2-a27b-adc84c8145a4	Open	CSV, XLS	#	Borough	~300	1998 - 2005; Annual	Inactive
Domestic Energy Efficiency Ratings	Data from certificates lodged on the Energy Performance of Buildings (EPB) Registers, i.e. on buildings which have been newly constructed, sold or let since 2008. Includes information on average energy efficiency ratings, energy use, carbon dioxide emissions, fuel costs, average floor area sizes and numbers of certificates recorded. Split according to dwelling type.	MHCLG	https://data.london.gov.uk/dataset/domestic-energy-efficiency-ratings-borough	Open	XLS	#	Borough	~9000	2008 - 2019; Quarterly	Ongoing

TrustMark Data Warehouse	Trustmark building Data Warehouse populated with info gathered by installers of ECO3 retrofit scheme installers (large proportion of retrofits will be using this scheme) about work undertaken and the property being improved. One of stated aims of this is to help industry understand the market, and to feed into property passports. Could provide figures on typical material requirements and release plus waste arisings from retrofit projects.	Trustmark	https://www.trustmark.org.uk/ourservices/data-warehouse	Open	Unknown	Various	Postcode	Not yet active	n/a	Not yet active
Energy Company ECO Data	Energy companies record data on all ECO3 scheme house retrofits they fund. This data includes: - Postcode and outpput area of building - Building information incl dwelling type, #bedrooms, tenure type - Type of measures installed and % of property measures installed on - Various other fields This information is gathered by energy companies are provided to Ofgem for upload to the ECO register, which is not open access.	E.ON	N/a	Private	Unknown	Unknown	Unknown	Unknown	Unknown	Ongoing
London Comparison Goods Retail Floorspace Need Scenarios 2011-2036	Produced scenarios for each borough's likely construction needs for retail floorspace for 2036. Likely to be inaccurate.	Experian/GLA	https://data.london.gov.uk/dataset/london-comparison-goods-retail-floorspace-need-scenarios-2011-2036	Open	XLS	£ (estimated turnover) m2 (estimated floorspace requirements)	Central Activities Zones / Town centres	Varies (multiple datasets available)	2011 – 2036	Inactive
Construction output: Value non-seasonally adjusted, current prices at sub-national level	Displays quarterly performance of construction market in all sectors (new housing, other new work [including+excluding infrastructure], repairs and maintenance); could be useful for viewing construction activity over time and as a factor in modelling.	ONS	https://www.ons.gov.uk/businessindustryandtrade/constructionindustry/datasets/outputintheconstructionindustrysubnationalandsubsector	Open	XLS	£	National	5760; 36 per quarter (1 per subsector)	1980 - present; Quarterly	Ongoing

Deloitte London Crane Survey 2019	Surveycarried out by Deloitte on office construction and refubishment activity in central London and some emerging zones (e.g. docklands). Surveys developers building new offices or undertaking significant office refurbishment of 10,000 sq ft+. Headline results include office construction rate; number of new construction schemes; square footage of new schemes commenced; rate of works by submarket location; number of completions. Also presents office construction outlook.	Deloitte	https://www2.deloitte.com/uk/en/pages/real-estate/articles/crane-survey.html	Resulting figures & stats publicly visible; based on privately held underlying data	Report	Various	Submarket' (zones within central London)	Unknown	Unknown how long surveys have been undertaken; Annual	Ongoing
Strategic Housing Land Availability Assessment	Database of quantity and suitability of land potentially available for housing development across London. Provides info on gross site area, identified housing capacity, and start/completion years.	GLA	https://data.london.gov.uk/dataset/shlaa-2017-approvals-allocations	Open (on condition of attributio n)	XLS, Shapefile	Multiple, qualitati ve and quantitat ive	Point location	Varies (multiple datasets available)	2017 - 2041	Inactive
GLA Population and Household Projections	Data on projected population and number of households to 2050, may indicate locations of need for housing, amenities etc. Various scenarios and trends modelled, includin age split, location split and others.	GLA	Housing-led population projections: https://data.london.gov.uk/dataset/housing-led-population-projections Employment-led popn projections: https://data.london.gov.uk/dataset/employment-led-population-projections Trend-based popn projctns: https://data.london.gov.uk/dataset/trend-based-population-projections	Open	XLS, PDF		Borough / Ward / MSOA	Varies	2011-2050	Ongoing
Glenigan Construction Outlook	Provides economic forecasts of the construction sector by region in the UK, as well as number of housing starts (I think). Could be used to model future construction requirements for Circularity Atlas.	Glenigan		Paid; unsure of ability to use in analyses	Unknown	£ / %	Region	Unknown	Upcoming year; Annual	Ongoing
ONS Population Projections	Population projections at citywide and local authority (incl borough)-level, split by age bracket and sex, per year up to 2043. Indicates that London popn expected to grow by ~1m. E.g. Merton population expected to increase by ~5500 (varies significatly from GLA projection for Merton)	ONS	https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/datasets/localauthoritiesinenglandtable2	Open	XLS	#	Borough	~575000		

Streetworks Register	Up-to-date information about current road and street works. Intended to enable the general public and other interested parties to easily locate Local Highway Authorities streetworks registers. Not available for download as a full dataset without special access. Data is vague, only providing qualitative description of works undertaken.	GeoPlace	https://services.geoplace.co.uk/street/street works-register	License-only	Map + online list	Qualitative description	Point location	Unknown	Unknown	Ongoing
Dwelling stock by tenure and condition	Provides counts of dwellings in each borough, with tenure grouped into LA-owned, registered social landlord-owned, other public owned, owner occupied and private rented dwelling. Condition is given as proportion of LA dwellings that fall below the “decent home standard”.	Office for National Statistics (ONS)	https://data.london.gov.uk/dataset/dwelling-stock-tenure-and-condition-borough	Open	XLS	#	Borough	~6000	2001-2011; Annual	Inactive
National Infrastructure Delivery Plan 2016-2021	Brings together the government’s plans for economic infrastructure over the 5 years from 2016 with those to support delivery of housing and social infrastructure. This is reflected by the government’s commitment to invest over £100 billion by 2020-21, alongside significant ongoing private sector investment in our infrastructure.	Infrastructure and Projects Authority	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/520086/2904569_nidp_delivery plan.pdf	Public	Report (PDF; underlying data not identified)	£ mostly, some #	National	n/a	n/a	n/a
English Housing Survey	Annual survey of the characteristics and conditions of a random sample of homes, generally with around 13,000 cases from across the country. Includes a wide range of relevant variables, including dimensions, construction type, materials, build period, previous modifications to building, building components and services present, age of internal and external building elements (or components), internal / external defects, structural faults, housing health and safety rating, pests, drains, local area and environment, amongst others. Does not cover all homes, however is considered to be a representative sample.	BRE	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/860076/2018-19_EHS_Headline_Report.pdf	License-only	Unknown	Multiple	Postcode	~13,000 per year	1967-present; Annual	Ongoing
JLL Property Predictions 2019	Forecasts 2019 - 2023 housing starts in London, and provides general economic analysis for various construction sector	JLL	https://www.jll.co.uk/content/dam/jll-com/documents/pdf/research/2019%20UK%20Property%20Predictions%20Full%20Report.pdf	Resulting figures & stats publicly visible; based on privately held underlying data	Report (PDF)	£ / #	City	Unknown	2019 - 2023	Unknown

Turner & Townsend - London construction sector analysis (2019)	Presents broad economic analysis for construction sector for London as of 2019. (See document p79). Data collected from a large annual survey, however no information on this survey is given.	Turner & Townsend	Report link	Resulting figures & stats publicly visible; based on privately held underlying data	Report	£	City	Single data point per indicator	Annual	Ongoing
Turner & Townsend - Building costs per m2 internal floor area for London (2019)	Stats on building costs per square meter of internal area for properties in London as of 2019, broken down by use class (airports, car parks, commercial, education, hospitals, hotels, industrial, residential, and retail; each of which has multiple sub-categories). (See document p78)	Turner & Townsend	Report link	Resulting figures & stats publicly visible; based on privately held underlying data	Report	£	City	Single data point per indicator	Annual	Ongoing
Turner & Townsend - Material costs (2019)	Stats on average costs of materials in London, including concrete, rebar, concrete blocks, bricks, structural steel, tempered glass panes, softwood framing timber, plasterboard, emulsion paint, copper pipe and copper cable. (See document p79)	Turner & Townsend	Report link	Resulting figures & stats publicly visible; based on privately held underlying data	Report	£	City	Single data point per indicator	Annual	Ongoing
Turner & Townsend - Composite trade rates; labour costs (2019)	Presents rates for various trades (per job) and labour costs in London. (See document p79)	Turner & Townsend	Report link	Resulting figures & stats publicly visible; based on privately held underlying data	Report	£	City	Single data point per indicator	Annual	Ongoing

Barbour ABI Economic & Construction Review	Provides construction market data split by sector (e.g. residential, infrastructure, commercial & retail, etc) and region. Note: Barbour ABI are used by ONS (Construction New Orders data), Hm Govt (National Infrastructure and Construction Pipeline) and the Construction Products Association. "uses Barbour ABI construction contract award data which acts as a leading indicator of current and future workload levels in the construction industry. It includes projects with a construction cost of over £100k, where a contract has been awarded to a main contractor. It is collated on a monthly basis and includes developer to build projects but excludes framework agreements and Masterplans. Values are taken at current prices and are non-seasonally adjusted. As its time series data we use a three month moving average to smooth out short term fluctuations and highlight longer term trends/cycles."	Barbour ABI	https://www.barbour-abi.com/wp-content/uploads/2018/05/1805181-ECMR-May18-Free-v1.pdf?utm_source=Adestra&utm_medium=email&utm_term=&utm_content=Download%20the%20report&utm_campaign=ECMR%20May%202018%20Registered%20-%2024.05.18	Paid (report; unknown whether underlying data available)	Report	£	Unknown	Unknown	Unknown	Ongoing
Indices of Multiple Deprivation	Statistics on relative deprivation in LSOAs in England. Domains include, amongst others: "Income"; "Barriers to Housing and Services", which includes e.g. distance to services and amenities, household overcrowding, and housing affordability; and, "Living Environment", including e.g. indoor living environment, housing condition, presence of central heating, and outdoor air quality. The indices (especially those listed above) may be used as indicators of the likelihood of different types of works in future, or of the types of building/neighbourhood transformation that will be necessary.	MHCLG	https://www.gov.uk/government/statistics/english-indices-of-deprivation-2019	Open	Excel spreadsheet	N/A	LSOA	32844 (assumed - this is the number of LSOAs in England)	2015 and 2019; Every 3-4 years	Ongoing

COPENHAGEN DATA SOURCES - REUSE, RECYCLING AND OTHER WASTE FLOWS										
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**	**Format**	**Units**	**Smallest geography**	**Volume of data**	**Time range & frequency of data collection**	**Ongoing/ Inactive/ Not yet active**
Waste generation	Waste production sorted by: - Year - Municipality, - Type of waste - Source - Treatment	The Environmental Protection Agency	https://mst.dk/affald-jord/affald/affaldsdatasystemet/find-affaldsdata/	Public	Excel	-	Municipality	Denmark	Annual	Ongoing
Treated volumes	Treated volumes sorted by: - Year - Type of waste - Treatment	The Environmental Protection Agency	https://mst.dk/affald-jord/affald/affaldsdatasystemet/find-affaldsdata/	Public	Excel	-	Municipality	Denmark	Annual	Ongoing
Recycling rates		The Environmental Protection Agency	https://mst.dk/affald-jord/affald/affaldsdatasystemet/find-affaldsdata/	Public	Excel	-	Municipality	Denmark	Annual	Ongoing
Waste generation by industry and households	Database AFFALD01: Waste generation by industry and waste category	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=AFFALD01&PLanguage=1	Public	Excel	Ton	Denmark	Denmark	2011-2017, Annual	Ongoing
Waste treatment by industry and households	Database AFFALD: Waste generation by industry, kind of treatment and waste category - Total - Materials recovery - Incineration - Deposition of waste - Special treatment - Temporary storage	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=AFFALD&PLanguage=1	Public	Excel	Ton	Denmark	Denmark	2011-2017, Annual	Ongoing
Waste generation of hazardous waste	Database AFFALD03: Waste generation by industry and hazardousness	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=AFFALD03&PLanguage=1	Public	Excel	Ton	Denmark	Denmark	2011-2017, Annual	Ongoing
Im- and exports of waste by waste category	Database AFFALD04: Im- and exports of waste by waste category, kind of treatment and imports and exports - Total - Materials recovery - Incineration - Deposition of waste - Special treatment - Temporary storage	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=AFFALD04&PLanguage=1	Public	Excel	Ton	Denmark	Denmark	2011-2017, Annual	Ongoing

Generation of waste caused by final demand	Database AFF1MU3: Generation of waste caused by final demand by industry and waste category - Cause - Waste category - Industry - Price unit	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=AFF1MU3&PLanguage=1	Public	Excel	Ton	Denmark	Denmark	2011-2017, Annual	Ongoing
Value of Environmental goods and services	Database GRON1: Environmental goods and services by environmental purpose, industry and unit - Environmental purpose - Construction industry - Manufacturing - Knowledge-based services - Export - Value aded - Number of persons employed	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=GRON1&PLanguage=1	Public	Excel	DKK or number	Denmark	Denmark	2012-2018, Annual	Ongoing
Environmental taxes by environmental category	Database MREG21: Environmental taxes by environmental category	Statistics Denmark	https://www.statistikbanken.dk/statbank5a/SelectVarVal/Define.asp?Maintable=MREG21&PLanguage=1	Public	Excel	million DKK	Denmark	Denmark	1995-2018, Annual	Ongoing
Building screening for environmentally hazardous substances	Screening of buildings before renovation or demolition of buildings. Done by private companies. Some reports are reported to the municipalities with the notification of building waste. The report normally includes a screening of following materials and chemical compounds: - Radon - PCB - Mold - Asbestos - Lead	Private buildings screening companies, Demolition companies.	-	Private	Report	Multiple	Building	Building		Ongoing
Companies that sell building materials for reuse	No main online platform	Various smaller companies	https://genbyg.dk/ https://tegllageret.dk/vores-produkter/ http://www.hc-genbyg.dk/ https://jensengenbrug.dk/ https://klassiske-vinduer.dk/ https://tegllageret.dk/ https://bregnebjerggaard-grusgrav.webnode.com/ https://jk-genbrugscenter.dk/ http://gamlemursten.dk/	Private						Ongoing

HAMBURG DATA SOURCES - REUSE, RECYCLING AND OTHER WASTE FLOWS										
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**	**Format**	**Units**	**Smallest geography**	**Volume of data**	**Time range & frequency of data collection**	**Ongoing/ Inactive/ Not yet active**
Survey on the processing and recycling of construction waste in Hamburg	This waste statistics provides information on the quantity, origin and whereabouts of household waste and similar commercial and industrial waste and waste from establishments such as offices, commercial operations, shops and markets, and road sweepings. A summary of the statistics on municipal waste is published annually and made available for download.		https://www.statistik-nord.de/fileadmin/Dokumente/Statistische_Berichte/verkehr_umwelt_und_energie/Q_II_4_2j_H/Q_II_4_2-j_16_HH.pdf	Public			Citywide		2016	Inactive
Use of secondary mineral construction material	Requirements for the recycling of mineral waste: Map for the assessment of the installation capacity of substitute building materials taking into account the groundwater corridor distances, flood plains, water protection areas and nature reserves.	info@bue.hamburg.de For water related issues: michael.schroeder@bue.hamburg.de	https://metaver.de/trefferanzeige?docuuid=59CCF77B-B8CC-4977-B7BF-6375DACF507D	Public			Public authority		2013, last change in 2017	Inactive

HELSINKI DATA SOURCES - REUSE, RECYCLING AND OTHER WASTE FLOWS										
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**	**Format**	**Units**	**Smallest geography**	**Volume of data**	**Time range & frequency of data collection**	**Ongoing/ Inactive/ Not yet active**
Data on construction waste	Amount of waste generated from new and repair construction and demolitions, split in waste classes (wood, paper, glass, metals, gypsum, plastics, concrete, electronical waste, asbestos and other. *Notes* : Based on data of building permit cases that are completed. Not actual amounts of waste generated.	HSY	https://hsy.fi/fi/asiantuntijalle/ilmastonmuutos/kiertotalous/jatemaarat_ja_kierratysaste/Sivut/default.aspx	public, partly open data			Helsinki Metropolitan Area		2014, 2015, 2016, 2018	
Data on construction waste, KEIKKA-project	Amounts of municipal waste and waste from construction split in waste classes + suggestions for policy instruments to increase recycling and reuse	Prime Minister's Office Finland	https://tietokayttoon.fi/documents/10616/2009122/53_2016+Kohdennetut+keinot+kierr%C3%A4tyksen+kasvuun.pdf/e883402b-13dc-4d69-8126-953c80cc1b8f/53_2016+Kohdennetut+keinot+kierr%C3%A4tyksen+kasvuun.pdf.pdf?version=1.0	Open data			National		2014	Inactive
Case study of amounts of waste	Materials (amounts of construction waste) of a demolished apartment building built in 1970's.	ARA / VTT	https://helda.helsinki.fi/handle/10138/41559	Public					2013	Inactive

YLVA	The environmental monitoring system where operators who have environmental permits e.g. demolition companies shall report the amounts of incoming, stored and outgoing waste and other environmental emissions.	The Centres for Economic Development, Transport and the Environment (ELY Centres)	https://ylva.ahtp.fi/	Public, restricted access			National		Annual	Ongoing
Waste statistics	Waste generated on different fields (19) and split by waste category (54). Annual data by industry describing wastes generated by industry (mining and quarrying, manufacturing, energy supply) and their treatment by type of waste. Data on amounts of waste generated in building construction and civil engineering.	Helsinki Region Environmental Services Authority HSY		Public, partly open data			Helsinki Metropolitan Area		Irregular	Ongoing

LONDON DATA SOURCES - REUSE, RECYCLING AND OTHER WASTE FLOWS

Title	Description	Source/ contact	URL	Accessibility	Format	Units	Smallest geography	Volume of data	Time range & frequency of data collection	Ongoing/ Inactive/ Not yet active
UK Statistics on Waste	Data showing biennial waste energy recovery/ incineration/ recovery other than energy recovery (not backfilling)/ recovery other than energy recovery (backfilling)/ deposit onto or into land/ land treatment or release into water bodies. Split according to type (mineral waste from construction & demolition and waste wood likely to be only relevant categories) and hazardous/non-hazardous. These statistics are compiled to comply with EC Waste Framework Directive (2008/98/EC) and EC Waste Statistics Regulation (2150/2002/EC) reporting requirements. Based on WasteDataInterrogator and WasteDataFlow.	DEFRA	https://www.gov.uk/government/statistics/uk-waste-data	Open	ODS; XLS; CSV	Various	Nation		2010 - present; Monthly	Ongoing
SmartWaste data	Data is collected from individual projects on quantities of waste produced, split by waste class, as well as location of project, type of works (e.g. new construction, refurb, demolition), type of building/asset. Provides a high level of granularity and precision on waste ariings from different project types. Data from all projects within a desired area (e.g. 1774 projects in London) may be aggregated to yield typical waste arisings from different works and different building typologies.	BRE	https://www.bresmartsite.com/products/smartwaste/	Special access to aggregate data	XLS	tonnes/100m2	Point location	912 (average tn/100m2 of 19 waste classes, across 12 building types, across 4 works categories; 19x12x4) Underlying data volume substantially higher	Unknown; Ad-hoc collection	Ongoing

London Waste Map Database	London Waste Map presents London's (as well as individual boroughs') permitted waste facilities using information provided by London waste planning authorities and the Environment Agency. For CDEW it includes facilities for: disposal; fuel preparation and MBT; materials recycling and sorting; metals and vehicle recycling. The database behind the map provides, for each facility, the following information: • Site name • Site type (e.g. transfer, treatment, disposal, recycling centre, organic waste; including whether deals with CDEW) • Majority waste type (hazardous/inert/household industrial and commercial) • Whether handles just one or multiple waste types • Licensed tonnage • Tonnage received (latest year) • Address is held somewhere (since the facilities are geolocated on the map) but doesn't appear in the datasheet Data is sourced from Environment Agency (i.e WDI and WDF) and directly from local authorities.	GLA	https://maps.london.gov.uk/waste/	Open	Various	Various	Point location	346 waste facilities, numerous data fields for each	2017 only, though uncertain because average tonnage received between 2014-2017 is available, but no data on individual years prior to 2017 is given. Annual; may lag behind by a couple of years (data available only up to 2017 as of Dec 2019)	Ongoing
Environmental Permitting Regulations - Waste carriers, brokers and dealers	Public register of all carriers, brokers and dealers of waste. The 'upper tier' register lists all companies that either carry (either as part of their own opertations, e.g. contractors, or as a commercial service, e.g. skip hire), broker or deal in construction and demolition waste. However, no sort function to seperate locations or type of waste so cannot distinguish the number and type of waste CBD operations by region or borough.	Environment Agency	https://environment.data.gov.uk/public-register/view/search-waste-carriers-brokers	Open	Seachable database; full raw dataset not found	Descriptions	Point location	Unknown	Unknown	Ongoing
Waste Contracts Register	'Contract register to monitor when waste authority contracts come up for renewal. The register is designed to be available for all waste authorities to view and support joint working and joint procurement opportunities. Joint working can provide better value for money on 'like for like' services and achieve service harmonisation across borough boundaries to help remove barriers to recycling.'	GLA	https://data.london.gov.uk/dataset/waste-contracts-register	Open	XLS	Description; date	Borough / waste authority	n/a	n/a; Ad- hoc collection	Ongoing

COPENHAGEN DATA SOURCES - OTHER POTENTIALLY USEFUL RESOURCES				
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**
HAMBURG DATA SOURCES - OTHER POTENTIALLY USEFUL RESOURCES				
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**
IHK Recycling market	Waste exchange portal. new recycling possibilities for waste or residual materials		https://www.ihk-recyclingboerse.de/?mod=start	Public
HBAW Hamburg / Hamburger Bau- und Ausbauwirtschaft	Hamburg construction and expansion industry		https://www.welt.de/print/die_welt/hamburg/article201618324/Bauwirtschaft-fordert-von-Hamburg-mehr-Recycling.html http://hbaw.hamburg/	Public
Zebau Holzbauforum	Wood Building congress		eranstaltungen/holzbauforum/	Public
Norddeutsches Zentrum für nachhaltes Bauen	North German Centre for Sustainable Building		http://www.nznb.de/	Public
Umweltpartnerschaft Hamburg	Environmental Partnership Hamburg		https://www.hamburg.de/umweltpartnerschaft/	Public
Deutsche Gesellschaft für Nachhaltiges Bauen	German Sustainable Building Council		https://www.dgnb.de/de/index.php	Public
Bewertung Nachhaltiges Bauen Bundesministerium des Inneren, für Bau und Heimat	Federal Ministry of the Interior, for Construction and Home Affairs		https://www.bnb-nachhaltigesbauen.de/bewertungssystem.html	Public

Umwelt Bundesamt	Federal Office for the Environment		https://www.umweltbundesamt.de/daten/ressourcen-abfall/verwertung-entsorgung-ausgewaehlter-abfallarten/bauabfaelle#textpart-1	Public
Vero-Der Baustoffverband	building materials association		https://www.vero-baustoffe.de/	Public
BVSE Bundesverband Sekundärrohstoffe und Entsorgung	Federal Association of Secondary Raw Materials and Waste Management		https://www.bvse.de/fachverband-mineralik.html https://www.bvse.de/themen-mineralik1/themen-mineralik/mineralik-marktbericht.html	Public
Bauteilnetz Deutschland	Initiative founded by Ute Dechanstreiter		http://www.bauteilnetz.de/	Public
Kreislaufwirtschaft Bau - eine Initiative der deutschen Baustoffindustrie, der Bauwirtschaft und der ntsorgungswirtschaft	Association of building materials industry		http://www.kreislaufwirtschaft-bau.de/	Public

HELSINKI DATA SOURCES - OTHER POTENTIALLY USEFUL RESOURCES				
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**
MuutosMallit / ReUSE and BEKO databases	Drawings and measures of aparment buildings built in 1960-80, collected from archives of The Housing Finance and Development Centre of Finland (ARA). Covers 230 apartment buildings. (ReUSE) Insulating material (thickness), outer layer ,surface materials and treatments of concrete element facades and balconies in 947 apartment buildings built in 1960 - 1990. (BEKO)	TAU		Requires access rights

Drawings of buildings	Archived plans and supporting documents of new-constructions and major alterations conducted. Also original material lists including amounts of material used in traditional finnish houses (rintamamiestalot).	Municipal building control services, The National Archives of Finland, archives of The Housing Finance and Development Centre of Finland	Example: http://digi.narc.fi/digi/view.ka?kuid=207784	Public

LONDON DATA SOURCES - OTHER POTENTIALLY USEFUL RESOURCES				
Title	**Description**	**Source/ contact**	**URL**	**Accessibility**
Green Guide	Provides material intensity data (i.e. quantity of materials) per 100m2 of different construction types. Useful for estimating material quantities of different typologies where actual material contents data is lacking.	BRE	https://www.bregroup.com/greenguide/page.jsp?id=3612	Special access for aggregated data
Building Information Model	• UK has mandated BIM on govt projects since 2016 • BIM is also widely used outside public projects, especially on larger projects • BS EN ISO 19650 standards, and various others • COBie is a spreadsheet data format for the publication of a subset of building model information focused on delivering building information (rather than geometric modelling), such as equipment lists, product data sheets, warranties, spare parts lists and preventive maintenance schedules. • Widespread use of BIM Level 3 would be an enabler of improved data capture since it would involve integrated data collection and storage from multiple contributors to a construction project. There may also be scope to collate BIM models in a centralised blockchain database. https://www.ukconstructionmedia.co.uk/features/bim-progress-adoption-uk/		https://bim-level2.org/en/standards/	
Design for a Circular Economy primer - Mayor of London	2019 report outlining the principles to create a circular built environment	GLA	https://www.london.gov.uk/sites/default/files/design_for_a_circular_economy_web_2.pdf	

Connected Open Government Statistics (COGS)	Users have difficulty in finding and using GSS data because: - Metadata (the information about data e.g. definitions, caveats, information about how the data was collected) is often kept separately to the data (e.g. in a methodology document) - There are lots of different departments producing data on a similar topic but there is no easy way to bring this all together. The aim COGS aims to fix this problem by: - Finding all the spreadsheets on a similar topic and bringing them together into "dataset families" - Putting these datasets into "Tidy Data" format by stripping out all the presentational stuff - Finding the metadata - Putting the Tidy Data and the metadata together and feeding it through a pipeline in order to get something called "Linked Data" Linked data is good because: - It makes data easier to find (search engines can work with Linked Data better than data in spreadsheets) - Users no longer have to navigate to different websites and different spreadsheets to find what they need - Search engines like Google can "scrape" the data to answer questions people type in - Technical users find it easier to build new tools with Linked Data - Linked Data allows online tools to be automated (e.g. dashboards can pull through the most up to date data automatically).	Government Statistical Service	https://gss.civilservice.gov.uk/guidance/the-gss-data-project/	

ISO37120 - Sustainable Development of Communities	Standards for 100 sustainable development indicators to be shared openly by cities to allow monitoring, tracking and targeting of interventions. These Circular economy-related indicators shared include building stock, housing tenure, informal settlements, waste (though none on CDW), and various others. Will soon be introducing a 'trends' function which will display projections of the various indicators. London and Helsinki are participants, but Copenhagen and Hamburg are not. Produced annually in theory, although many do not display recent years (probably because of lag time in data collection).	World Council on City Data (WCCD)	http://open.dataforcities.org/	Public
ETIM	"Format to share and exchange product data based on taxonomic identification. This widely used classification standard for technical products was developed to structure the information flow between B2B professionals." "Lays the foundation for a wide variety of applications, from product databases to product data management software." A data model with 6 key elements: 1. Product groups 2. Product classes 3. Synonyms (and keywords) 4. Features 5. Values 6. Units In the UK, ETIM is split amongst electro-technical (led by the Electrical Distributors Association), HVAC and sanitary products (led by the Builders Merchants Federation) and building products (also led by BMF).	ETIM-UK Ltd	https://www.etim-uk.co.uk/etim-uk-ltd/	

Global Urban Metabolism Dataset	Metabolism of Cities initiative to Gather data from a variety of research studies that have calculated particular values (material extraction, emissions, construction material use, imports, exports, etc.) for an urban/provincial region. The metabolism indicators also take into account energy, water, air pollution as well as urban characteristics indicators. Final goal is to provide a centralized, consistently formatted dataset of data pulled from a variety of studies, maps to visualise where studies have been done and what the outcome was. Data can be filtered by city (has data for London, Hamburg and Helsinki), category (incl materials and waste among others), year and more. Not much data available for more recent years in the 3 relevant cities, but this could be an opportunity to share any MFA or datasets used in CIRCuIT.	Metabolism of Cities	Description of project: https://archive.metabolismofcities.org/data Dataset available at: https://archive.metabolismofcities.org/page/casestudies/download	Public
MultipliCity	Successor to GUMD (above) developed by Metabolism of Cities. Aims to be a user-friendly, centralised data platform for data on (urban) resource flows and stocks. Short-term goal is to enable crowdsourcing of the groundwork and desktop research that is required for urban metabolism research. Any student, city official, or interested party can upload a dataset to the system. After initial data loading stage, it is planned to expand the system with a number of tools and utilities that assist analysis and interpretation of the datasets. Source code is freely available and all data can be accessed without restrictions.	MultipliCity		
Metabolic	"Metabolic advises governments, businesses, and NGOs on how to adapt to a fast-changing global context, while creating disruptive solutions that can dramatically shift how the economy functions. We crunch data, provide strategies and tools, build pilots, and create new ventures that develop scalable solutions to critical problems. Core to achieving our mission is the transition to an economy that is regenerative and 'circular' by design." Process based on Material Flow Analysis.	Metabolic	https://www.metabolic.nl/about/#about	

C3.ai	AI platform allowing manufacturing and distribution enterprises to develop solutions for "predictive maintenance, fraud detection, sensor network health, supply network optimization, energy management, anti-money laundering, and customer engagement." These solutions could help to optimise the supply chain overall and reduce wastage; C3 and similar platforms represent an opportunity to increase the circularity of the businesses operating within the construction supply chain of a city.	C3	c3.ai	
Reflow	"An EU H2020 funded project, from 2019 to 2022, that seeks to understand and transform urban material flows and to co-create and test circular and regenerative solutions at business, governance and citizen levels." Not explicitly looking at construction materials, mostly other types of wasteful activities, however will be utilising big data techniques, urban metabolism, Material Flow Analysis, etc.	Reflow	https://reflowproject.eu/	
Demolition Refurbishment Information Datasheets (DRIDS)	Compiled by the NFDC, DRIDS allows NFDC members to find the most efficient and environmentally friendly waste stream for demolition arisings, find the nearest recycling sites, reclamation yards, composting facilities, transfer stations and landfill sites. Covers a wide range of products and materials, including flooring, plasterboard, hazardous, inert, metal, plastic, wood, organic matter, insulation, packaging, electrical, composite, and misc. There may be data collected by or known to the NFDC relating to this.	National Federation of Demolition Contractors	http://nfdc-drids.com/	
Public Sector Mapping Agreement (PSMA)	Collective agreement between OS and the government that allows public bodies to use OS data, and to share data with contractors.	Ordnance Survey	https://www.ordnancesurvey.co.uk/business-government/licensing-agreements/public-sector-mapping-agreement	
SAP Plastics Cloud	SAP are creating what is essentially a materials exchange portal for plastics, putting manufacturers of plastic products in touch with suppliers of recycled plastic.		https://news.sap.com/2019/09/plastics-cloud-pilot-new-global-supplier-marketplace/	

AccuCity and Landmark	London BIM-linked 3D mapping partnership		https://www.pbctoday.co.uk/news/bim-news/bim-ready-3d-models/67635/	
Prism	Initiative to create an open-source database and app to accelerate the design process for precision manufactured housing in London. Contributed to by a large number of influential stakeholders including the Mayor of London, Homes England, TfL, and a large number of developers, engineering firms, product manufacturers and professional services organisations.	Prism	https://www.prism-app.io/index.html	
REAP: Flooring	Provides data on amount of waste generated and % flooring waste to landfill based on "independent market data and discussions with relevant bodies. No single set of data covers the whole of the sector. Due to the lack of a classification of waste flooring it is difficult to arrive at an estimate of material actually thrown away." 1st recommendation was to work towards improved data collection for the whole sector; action (by end 2010) was to produce an agreed set of definitions for reporting of flooring waste.	WRAP; Contract Flooring Association; BRE	https://www.wrap.org.uk/sites/files/wrap/Flooring_REAP.pdf	Figures & stats publicly visible; based on privately held underlying data
REAP: Joinery	Presents estimates of wood consumption and waste wood production in the UK (all pre-2009). These were mostly compiled based on information from associations such as the Wood Recyclers Association, TRADA, the British Woodworking Federation, and the Wood Panel Industries Federation. Also presents results of a 2009 survey of BWF members on uses for wood waste, plus an analysis of the market for waste wood provided by the WRA. APPROACH THESE TO SEE IF DATA COLLECTION IMPROVED, AND WHAT EXISTS.	WRAP; British Woodworking Association	https://www.bwf.org.uk/wp-content/uploads/joinery-resource-efficiency-action-plan.pdf	Figures & stats publicly visible; based on privately held underlying data
REAP: Mineral wool ceiling tiles	Figures on mineral wool ceiling tile market for the UK plus approx volume of product (both based on research by AMA commissioned by WRAP); major manufacturers; esstimated number of suppliers and installers. Stated that at time of publication (2013) it was impossible to calculate exact amount going to landfill, though it is estimated that a large quantity did.	Association of Interior Specialists	https://www.thefis.org/wp-content/uploads/2015/10/Report_14_Ceiling_Action_Plan_for_print_-_FINAL.pdf	Figures & stats publicly visible; underlying data not identified

REAP: Precast concrete (2013)	Action point is for British Precast to 'review all questionnaires and guidance in respect of the data capture in association with KPI data annual surveys.' Not much in terms of actual data or figures.	Mineral Products Association	https://www.britishprecast.org/Sustainability/The-Precast-REAP.aspx	
REAP: Ready-mixed concrete (2014)	Provides some industry stats, which are covered by the Sustainable Concrete Forum KPIs (see down page). Recommends improved data capture beyond factory gate; states that no detailed analysis of the drivers and implications of product use, transport and logistics, wastage or end of life has ever been conducted.	British Ready Mixed Concrete Association	https://www.brmca.org.uk/documents/Ready_Mixed_Concrete_REAP_028_WRAP_BRE_BRMCA_Feb_14.pdf	Figures & stats publicly visible; underlying data not identified
Sustainability Action Plan: Plasterboard (2010)	Various targets and action plans which inherently require data collection for monitoring, and organisations or groups responsible for making these happen - however no information or data is made available online. Plasterboard Sustainability Partnership is in charge of monitoring against action plan - they or their members (see Action Plan) would be key.	DEFRA	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69303/pb13439-plasterboard-101019.pdf	Figures & stats publicly visible; underlying data not identified
Sustainability Action Plan: Windows (2010)	Stats cited: • UK windows stock is estimated at 230m units, increasing by around 1.5m units a year (MTP Windows Briefing Note) • Approx 9m windows sold each year; around 67% supplied as replacement windows (Trade Sector Profile: Domestic Glazing June 2007, Purple Market research Ltd) • UK collected and recycled 25,479tn PVC window frames from demo waste through Recovinyl (no citation) [from 2013 update report]	DEFRA	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69302/pb13438-windows-101019.pdf	Figures & stats publicly visible; underlying data not identified