METABOLIC

City of Amsterdam

Copper8

Digitization within the circular built environment

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After reading this article, you will:

- Understand how digitization contributes to designing, planning, transforming, construction, and demolishing the built environment at different levels of scale: building, area, and city-wide
- Gain insight into the possibilities and opportunities that different software and information systems offer for the circular design and sustainable management of buildings
- Learn which opportunities and possibilities that the various software and information systems offer for circular development area projects
- Know which data and information is needed to accelerate the transition to a circular built environment using software and systems
- Learn which insights these data, software, and models can generate and illustrate

Summary

Digitization can facilitate the circular design and management of the built environment, as well as the high-value reuse of raw materials. There are options for all levels of scale: building, area development, and even for the entire city or region.

At a building level, Building Information Models (BIM) facilitate circular and modular design, and Materials Passports ensure end-of-life reuse for buildings. Meanwhile, digital twins enable sustainable management during the use phase. By linking spatial data from Geographic Information Systems (GIS) to material and energy flows and related impacts, circular area development can become more concrete during every phase of the Planning and Decision-Making Process for Spatial Measures (PLABERUM). At the level of the city as a whole, digital models of material flows and digital marketplaces can facilitate the high-value reuse of materials and resources.

Definition

In this article, digitization refers to the introduction and increasing use of information, communication (ICT), and derived technology and related products, models, and technologies—for the design, planning, transformation, construction, and demolition of the built environment at different levels of scale.

Recommendations

- → Use digital tools (BIM, GIS, digital twins) and databases at all spatial scales to enable sustainable design, management, and cycle creation.

- → Actively monitor and register which materials circulate within the municipal boundaries and pinpoint energy performance and water management within the built environment. Also analyze the environmental impact and economic value associated with the flows. Municipalities, knowledge institutions, and the market can collaborate on these efforts.

- → As a municipality, use traditional policy instruments (from tenders and permits to procurement and subsidies) to collect valuable information whenever possible, and make it available to the entire chain. For example, link permits for demolition and new construction to data about the materials stored in a building. This makes it clear where, when, and from whom these materials become available for reuse.

- → As a municipality, assume a role as a data broker, together with knowledge institutions. Focus on storing information and making information available to all stakeholders. Make this information accessible and valuable to the market.

- → Where possible, use policy to encourage the market to use software for sustainable design and improving building performance. Use digital marketplaces and platforms to stimulate materialization and high-value reuse of materials throughout the chain.

Substantive deepening

Digitization at different levels of scale: building, area development, city-wide

As stated earlier, digitization offers opportunities at various spatial scales for the circular and sustainable design of the built environment. This section presents the options at all levels, from building, to area development, to exchanging materials at a city and regional level:

The building level: circular design with Building Information Models (BIM) and Materials Passports

Buildings are increasingly being designed, managed, and demolished digitally. This creates plenty of opportunities to apply a circular approach. By using Building Information Model (BIM) systems for the design phase, the digital foundation can be laid for the creation of material cycles at the end of the life cycle and for sustainable management during a building's use phase. A BIM is a 3D model of a building. Compared to a 2D drawing, a 3D model allows for the storage of much more information about the structure of the building and keeping it for later use.

What is a BIM?

A Building Information Model (BIM) is a digital model of an existing and/or planned structure, made up of objects linked to information. In addition to the geometry and position of, for example, a wall in such a model, information can also be added about materialization, the way in which connections are made, or about the financial value of elements and products. The object-oriented information can be linked to several things, such as phasing, purposes, required structural strength, and specific connections to surrounding objects.

In the design phase, a BIM can help coordinate all positions of elements, dimensions, and connections between elements, instantly and in detail. Prefabricated construction and designing and shaping elements in detail in the factory saves construction time. When the materials, products, and connections used are included in the BIM with enough detail, it is easy to look up how the building can be assembled and which elements can be reused later on. One condition is that any renovations that take place after completion must be recorded in the model. With the digital storage of the correct information, the residual value of materials, sub-products and other parts of the building can increase many times over, thus making cycle creation in the form of reuse an interesting revenue model. In the event of renovation and maintenance during the use phase, information about the different building layers' technical life can be found in the 3D model (see the article Circular Design). This is useful for planning maintenance and renovation, especially when managing a large property portfolio. Sustainable alternatives can also easily be selected based on all information associated with specific objects in the model. This information can of course be viewed directly in the BIM itself, but to make it available to a wider audience, it can also be translated from the BIM into a Materials Passport.

The building level: sustainable management and use through a digital twin

A circular building is not only constructed from circular or easily reusable materials. During the use phase, it also contributes to the creation of energy, water, and material cycles (waste streams). To facilitate this, a supplementary digital model and management system can be set up for the building, in addition to the BIM and Material Passport, known as a digital twin. In a digital twin, data is collected on factors such as the demand for heat and electricity, water consumption, or waste production. These patterns are linked to the occupation and use of the building during the day and evening. Data about the physical building is collected by sensors and directly fed back and analyzed by the building's management software. This data can be collected day and night, throughout the year. By analyzing the data at various moments and setting up smart and/or learning systems that respond to the data, the demand for energy, for example, can be significantly reduced. Data can reveal how to use spaces more efficiently or when to heat or cool specific parts of the building during specific periods of time.

The area level: data and digitization

As indicated in the municipal theme study for circular area development, digitization is also important to the circular development and management of the built environment at the area level. This may involve the creation of material cycles during the construction and use phase, as well as the design of public spaces and the development of sustainable and circular infrastructure (such as smart grids, new sanitation, mobility systems, waste processing systems). In order to shift toward circularity for area development projects, data and software are needed at various phases of the development process. Whereas buildings use BIM, geographic information systems (GIS) are an important tool for planning, design, and monitoring at area level.

Geographic Information Systemsdigitization

A **geographic information system (GIS)** is an information system with which (spatial) data or information about geographical objects (geo-information) can be stored, managed, analyzed, and presented. Just as in BIM, in which properties of a building element can be linked to a specific object, a GIS system makes it possible to link information about geographic objects to a specific object or location. Just as with a building, a 2D map can be printed out based on maps and spatial data in GIS or one can work in 3D (as in BIM). GIS and related software have already been used by governments and companies in area development projects for a considerable length of time, to analyze the existing situation in an area or for recording various spatial plans and the urban design, for example.

The area level: digital tools at every phase

Various digital tools can be built from existing, public GIS data to enable circular area development. This often requires a combination of existing public GIS data and new information and models to link GIS data to data on material and energy flows and related impacts. We will discuss the options for the different phases of the Planning and Decision-Making Process for Spatial Measures (PLABERUM)

1. Exploratory phase:

New spatial data and software offer municipalities and urban planners the opportunity to look at the city with fresh eyes and new insights. First and foremost, existing value should be preserved (see R-Ladder), and software and digital models are instrumental to mapping that value. For example, it is possible to predict which materials and building elements are stored in existing buildings and which part of these can be preserved during transformation or be designated for high-value reuse. "Soft values" can be mapped in the same way as well, such as spatial quality and identity, quality of life, or social cohesion in the neighborhood.

2. Feasibility phase:

The feasibility phase determines the manageability of the risks and thus the feasibility of the project. In the case of circular area development, for example, it examines to what extent a (de)centralized cycle system is possible, which infrastructure can be integrated into the area above and below ground, and what environmental space is available. In order to decide how best to design a cycle system, an estimate should be made of the material and energy flows in an area during the construction and use phase, as well as the relevant impact of design decisions and technological interventions, in addition to traditional feasibility studies.

Software and data are vital for such an analysis. Material flows and their related impact can be predicted and estimated for a variety of scenarios and designs, based on a combination of public data and models designed by consultancy firms. Public data, for example, can be generated from municipal GIS data, but also from databases such as the National Waste Control Center (LMA), the Key Register of Addresses and Buildings (BAG), the national waste monitor, or data from Stichting LISA containing the location and size of companies. By linking key figures on used building materials, energy performance of the built environment, the use of materials, the waste production of production processes at companies, or the consumption patterns and waste streams per household, a model can illustrate the main raw material flows and sustainability impacts in an area.

3. Design phase:

The same models can then be used to quickly validate different solutions and adapt these to the market. This addresses choices for building volumes and densities, other programming, maximum building height, or the orientation and positioning of buildings. Each has their own implications. A south-facing orientation can reduce the energy consumption of buildings. Higher densities and high-rise buildings generally mean a higher demand for energy and building materials. The position and orientation of buildings affects the productivity of solar panels. The preservation of existing buildings reduces impact and use of resources. In order to make a model of current and future flows, interventions can also be weighed against each other quickly and easily and selected for impact and feasibility. Ensuring that data on these flows is streamlined into a single model makes it accessible to design teams, developers, as well as town, country,

Image 1. Linking data about the materialization of the built environment to public GIS data (for example the Key Register of Addresses and Buildings), reveals which materials are stored in the Urban Mine. (Source: PUMA)

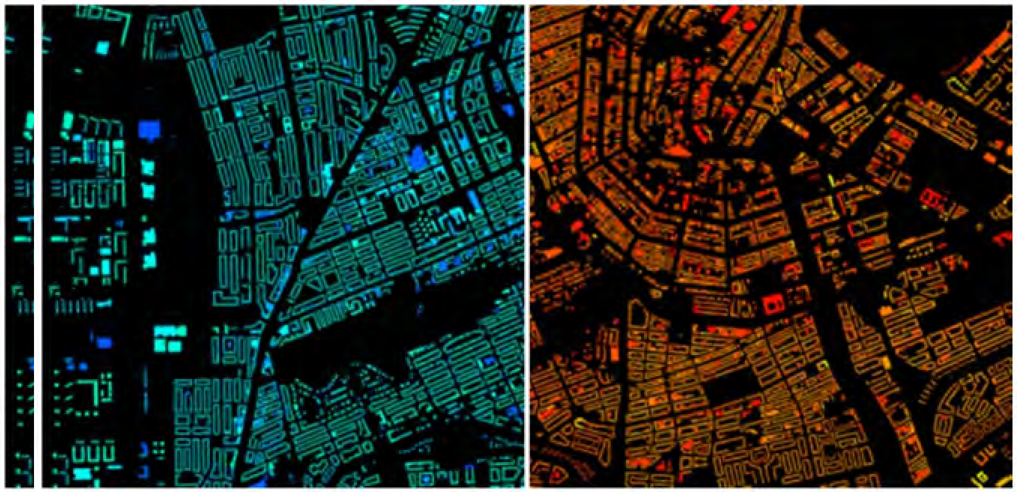
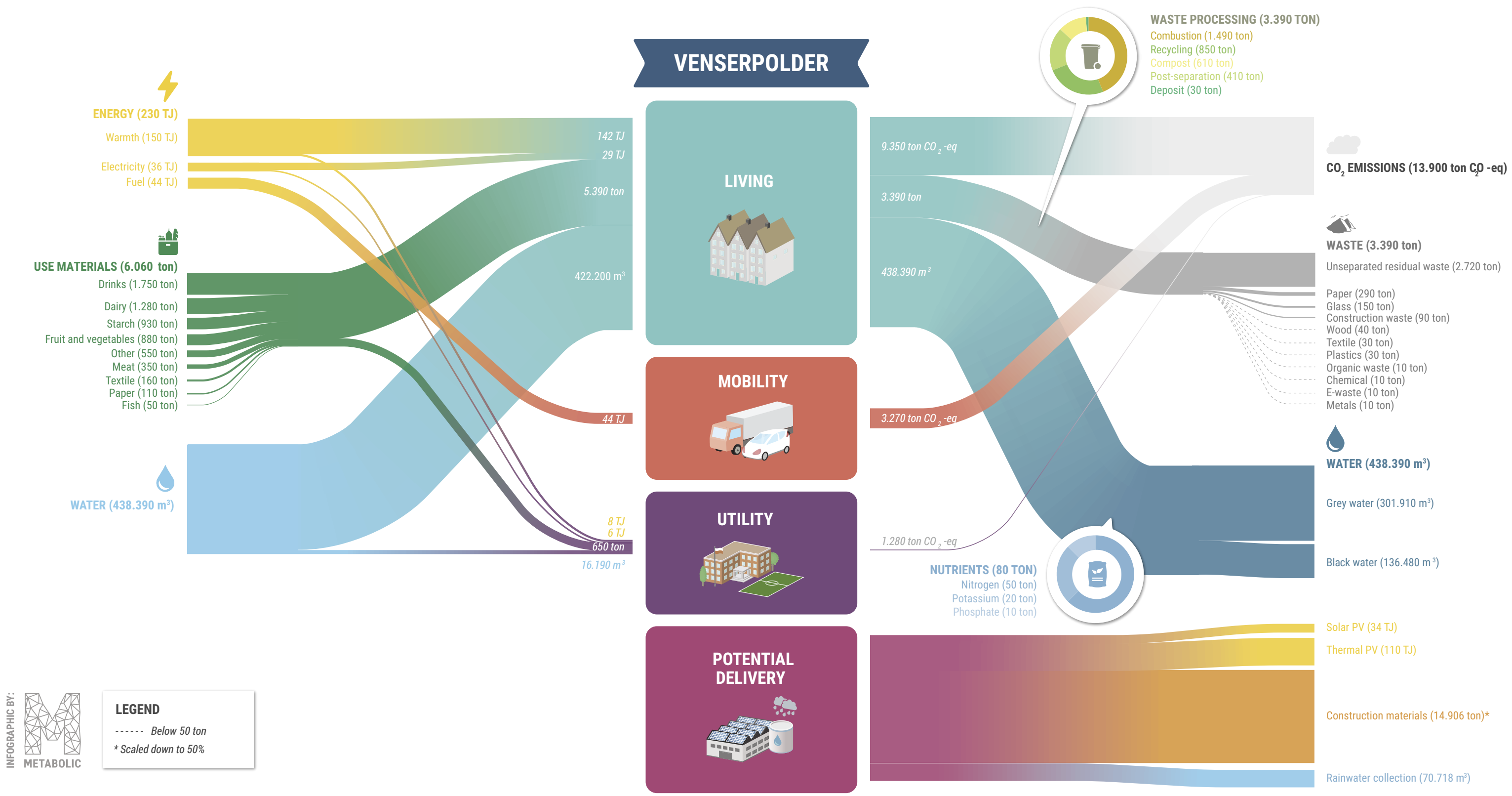


Image 2: Example of a Material Flow Analysis at area level for the Venserpolder district, Amsterdam. It is based on a combination of public spatial data, key figures, and models for estimating material and energy flows.



and urban planners on the municipal project team. This also paves the way to integrate circularity into the design.

4. Implementation:

In the implementation phase, it is important to guarantee that the objectives and design principles are indeed realized and ensure that the information required for high-value reuse is secured at the end of the life cycle. One way to achieve this is by setting the condition that buildings and infrastructure must be delivered with a Materials Passport (possibly in a BIM), for land allocation and tendering processes. At the same time, the reuse of existing materials within the area, city, or region can be facilitated during implementation at (temporary) physical construction hubs or digital marketplaces that foster the exchange of materials (see examples below).

5. Usage and management:

As with buildings, digital twins also enable smart and sustainable management in the use phase at the area level. On top of the usual building management systems, extra options are available at the area level. For example, smart energy exchange between buildings is already taking place at the Schoonschip housing project, via sharing platforms for mobility, lighting in public spaces, and the collection and processing of waste. With all these solutions, it is vital that smart monitoring and management systems provide instant feedback data to users about energy, water, waste, and mobility in order to stimulate sustainable behavior.

The city level: digitization for material flows

Systems for the digital mapping of material flows and environmental impact can also be designed city-wide. For example, Amsterdam is developing a Monitor for Circular Economy in which environmental impact, as well as social values and objectives for the city, can be measured. An example of a city-wide material flow analysis is the European research project REPAiR, in which both building materials and organic residual flows have been mapped for the Amsterdam Metropolitan Area.

At this stage, such analyses have been performed in Amsterdam for a large number of material flows. The government, the market, and knowledge institutes bring together the data needed for monitoring raw material flows and sustainability performances of the built environment through research projects such as these. At the same time, physical construction hubs and digital marketplaces create the infrastructure to exchange and reuse raw materials at the end of the life cycle.

Figure 3: Visualization of organic residual flows in the Amsterdam Metropolitan Area. As with material flow analyses at area-level, REPAiR also worked with a combination of public spatial and economic data, as well as specific models and key figures for the relevant material flows.

Example 1

Madaster, a digital platform for materials

Madaster is like a land registry for materials, an online platform that stores the value and location of raw materials, elements, and products for buildings. Madaster's mission is to make materials permanently available by giving them an identity on its platform. When materials have an identity, they become a source for reuse and each building is designed as a depot of materials with a defined value.

Madaster has developed a cloud platform on which information from Materials Passports is stored. For example, this can be in relation to the value, environmental impact, the technical specifications, or the way in which a material, element or product is incorporated in a building. Not only does Madaster make it easy for building owners to view this information, but third parties have also been given access to this information by the owners. Within Madaster, it is possible to work with both 2D drawings (IFC files) and BIM files.

Example 2

Digital marketplaces: Excess Material Exchange, Oogstkaart, and Insert

Digitally storing information about materials and products to create a circular economy is not enough. The range of circular materials and products must be visible to everyone. Supply and demand must converge, such that material flows that are becoming available (including construction materials and products) can be actively linked to each other. Several digital marketplaces have now emerged in the Netherlands toward that end.

For example, the Amsterdam Excess Materials Exchange (EME) created a digital matching platform, on which the highest-value reuse solution is sought for the materials and products on offer. The reuse potential of materials, products, or waste streams is mapped out on the platform. EME also maps the financial value of the flows in a certain reuse scenario and the potential environmental benefit. By linking the demand from specific and potential buyers to the supply, the transition to a circular economy can be accelerated through matchmaking.

The Oogstkaart platform fulfills a similar purpose specifically for building materials and actively brings together supply and demand. When a request for or offer of materials is received via the website, "material scouts" contact both the requesting and offering party to create a potential match.

The Insert platform specializes in things such as bringing together supply and demand within civil and hydraulic engineering and the public space.