Digital technologies will deliver more efficient waste management in Europe



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Digitalisation is transforming the 21st century, affecting every area of daily life, including the environmental technology sector. Digital technologies will deliver more effective waste management regimes. They will allow Europe's economy to recover more of the valuable materials present in waste streams, reducing the amounts of raw materials mined or imported and avoiding the associated environmental and climate impacts.

Key messages

1. An increased use of digital technologies is crucial to shifting European waste management towards more sustainable materials management. Such technologies improve recycling, facilitating the use of recyclates by producers, enabling better purchasing and sorting decisions by consumers, and improving waste sourcing options for recyclers.

2. Advanced digitalisation in waste management and treatment is currently mostly in the innovation phase. New business models, such as waste e-trading platforms, and waste-specific software and business analytics are emerging.

3. Digital technologies can be found in all steps of the waste management process, with some already in widespread use. The current situation in Europe, however, is heterogeneous, with different technologies being applied at various scales.

4. The digital transformation of the waste management sector should be aligned with plans to make greater use of digital technologies in the development of a circular economy.

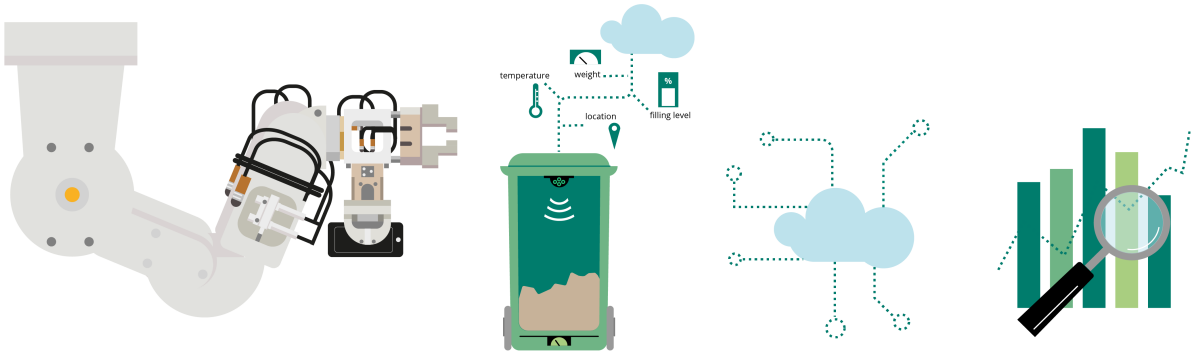
This briefing provides an overview of the potential for a digital transformation of the European waste management sector. It is based upon on the underpinning report by the European Topic Centre on Waste and Materials in a Green Economy (ETC/WMGE).

Using digital technologies in waste management

The uptake of digitalisation technologies across society is largely a result of continuing advances in miniaturisation, increased processing power and falling costs. Waste management is no exception, and it is also benefiting from improving digital technologies.

Examples of specific digital technologies that are currently used and expected to have a major impact in future on the efficiency of the waste industry include robotics, the internet of things, cloud computing, artificial intelligence and data analytics (Figure 1).

Figure 1. Use of digital technologies in waste management



	Robotics	Artificial intelligence and neural networks	Internet of things	Cloud computing	Data analytics
PROCESS	Advancements in the pneumatic sorting process as a result of automation technology allow producing defined waste streams of high purity (over 90 %).	Machine learning — using neural networks based on the use of data or examples to solve problems without explicit programming — is used for classification and pattern recognition in the waste management context, improving the efficiency of sorting.	As more and more devices are connected to the internet or other networks, sensor-supported containers can collect data and transfer it to central units.	Storing and processing of sensor data and cloud based software solutions make it easy to optimise workflows and document failure to collect, failure in sorting or detect waste bins that are not paid for.	Processing and analysing data plays an important role in the recycling industry in order to identify patterns, extract information, discover trends or calibrate models. This knowledge is important in order to evaluate different options for the transition to a recycling economy.
EXAMPLES	- Robots that are able to identify and sort recyclables and critical materials through image recognition/IR scanning/ AI vision systems when dismantling used phones/electronics	- Autonomous, self-driving street sweepers, refuse trucks	- Smart waste bins with identification systems, weighing systems, level sensors, temperature sensors, sofware for optimising logistics	Cloud based software for: - Connection, standardising and optimising internal procedures - Real-time order management, route planning and optimisation, customer self-service, order-tracking and evaluation	- Electronically supported diposition of waste collection vehicles - Evaluation of sensor data for automated sorting plants - Control of waste incineration plants - Drone based data collection on landfills

A revolution in waste management logistics

Digital technologies are increasingly applied across almost all areas of waste collection. Certain aspects of collection have been transformed by advances in digitalisation, especially logistics — the process of organising, scheduling and dispatching tasks, personnel and vehicles. Here, digital tools offer the potential to enhance the process by storing, processing, analysing and optimising the necessary information. Information generated during the collection process, e.g. on task progress or incidents, can be monitored in real time.

As greater volumes of information are collected, so complexity grows. In such instances optimisation algorithms help find the most suitable options for allocating resources such as workforce or vehicles. Important technologies include telematics, including routing systems, navigation and vehicle tracking software, enterprise resource planning (ERP) systems and similar. The resulting improvements are most apparent in increased efficiency. Another example is the so-called internet of things, including applications such as smart bins and robotics for semi-autonomous waste collection vehicles.

There remains substantial room to improve the waste collection process in the future and to align it with the needs of a circular economy. For example, it needs to be able to respond more flexibly to changing waste patterns and targets, or to facilitate the implementation of on-demand and customised services (ISWA, 2019).

Another part of waste collection is the process of documentation, communication and billing. Here, the ongoing switch from paper-based administration systems to digital systems, as seen in other industries, will further increase the efficiency of processes and flow of information. The technologies involved include digital identity tags for waste bins and containers, digital order processing, digital billing and payment, digital user interfaces for communication with consumers, and connecting public waste collection providers with other relevant governmental databases.

If these digital technologies are applied in documentation processes, they can be used to gather waste-related data from the public. Turned into valuable information by data analytics, they can support a circular economy through ‘a better understanding of the spatial and temporal patterns of waste generation’ (ISWA, 2019). In addition, the potential to collect many single data points instead of just reporting cumulative values can give local authorities further insights.

Digitalisation as a means to incentivise green behaviour

Pay-as-you-throw systems become more feasible using digital identification and billing techniques. These systems allow for a ‘fair’ billing scheme by allocating costs proportional to the amount of waste generated. It has been shown, however, that such schemes can have negative effects through attempts to avoid paying, such as increased illegal littering, use of public bins and ‘waste tourism’ to neighbouring regions with traditional billing schemes (Kinnaman, 2009).

Digitalisation also enables the development of advanced ‘know-as-you-throw’ schemes. In these schemes, waste management operators use radio-frequency identification (RFID) to monitor waste fractions at household level. A chip follows the waste and, once the operator has determined the quantity and quality of separation, this information is automatically fed back to the individual or company who generated the waste. Providing tailored messaging — e.g. appreciation for waste savings or good separation behaviour — can help nudge consumers towards better waste management practices, intersecting with waste prevention programmes.

Reducing costs and reaping the opportunities of automation

Waste management operations are a complicated logistical challenge involving substantial manual handling and, hence, labour costs. Digitalisation offers opportunities to reduce these costs and create better employment opportunities in higher value parts of the business chain.

One important field of application is the sorting process, which is a prerequisite for high-level recycling. AI image processing techniques supported by robotic sorters are developing fast and are already used by several global manufacturers of commodities such as electronics. Other approaches include the labelling of products using watermarks, quick-response (QR) codes or other kinds of digitally readable markers. These can support automated sorters by feeding them information on the material composition and product set-up, facilitating the recovery of high-value materials.

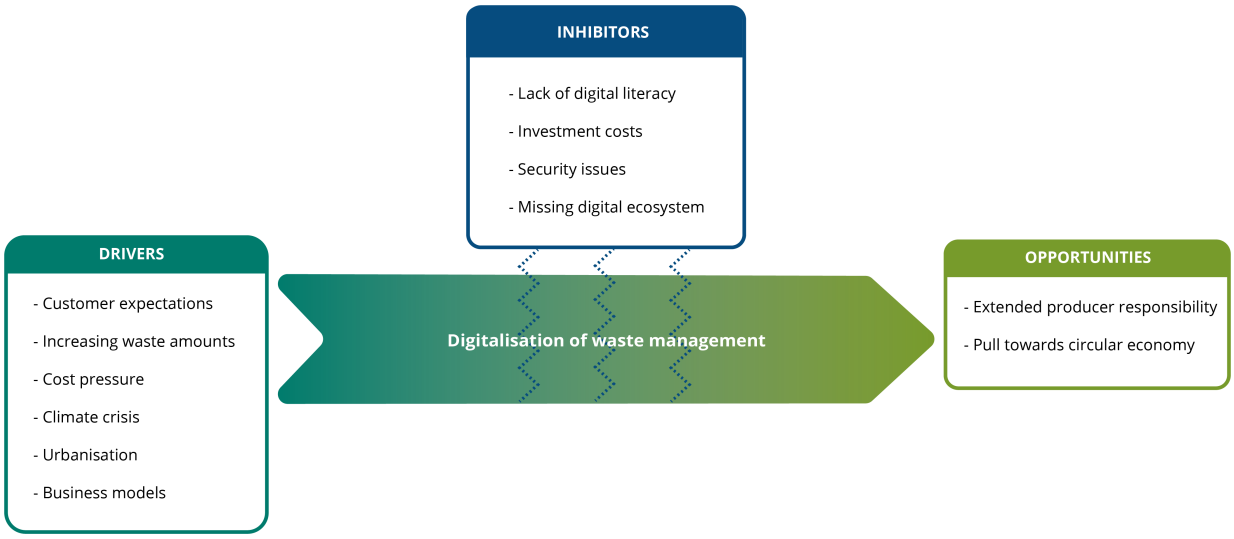
Robotic sorters can also generate information on the sorted materials, further optimising the subsequent processes or improving the AI. An example is the use of these data streams to predict patterns in incoming loads of waste and to learn about the waste sorting efficiency to predict the set-up of sorting lines. If these data are linked to other relevant data, such as prices in secondary raw material markets, then processes can also be adjusted accordingly.

Drivers and inhibitors

The waste management sector operates with low margins, is highly competitive, and continuously under pressure to reduce costs. Digital technologies require investment, but they also offer scalable efficiencies.

The report on digitalisation by the European Topic Centre provides further details of the main drivers and inhibitors of the digitalisation process. It identifies a number of economic, societal and technological barriers (Figure 2).

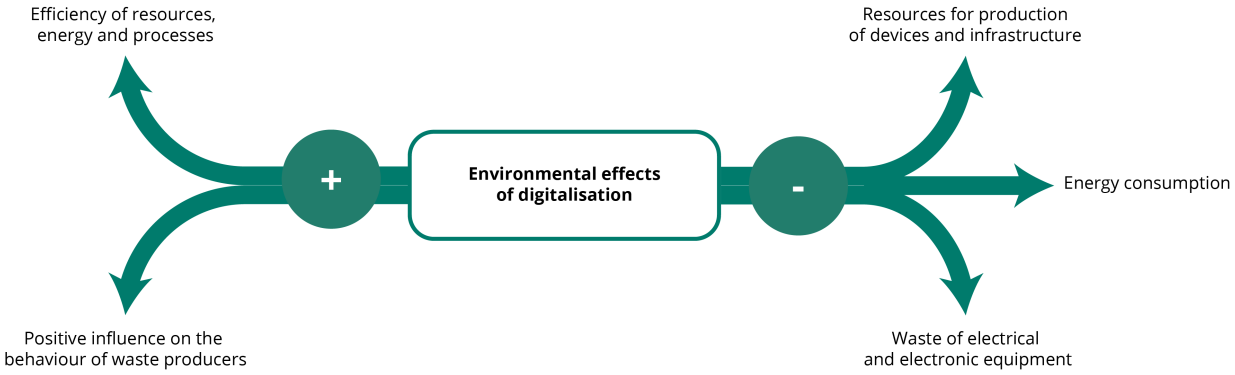
Figure 2. Examples of drivers and inhibitors of digitalisation



Environmental trade-offs created by increasing digitalisation for waste management

Greater digitalisation can help achieve circular economy goals across the waste management cycle, from the material sourcing, production and use phases through to the reuse of resources. However, the digital transformation of Europe's waste management infrastructure may create several generic trade-offs (Figure 2). The first is energy use. Supporting digital technologies can involve substantial energy requirements. A second concern is the material use required to produce the infrastructure, computing machines, the sorting robots and other elements. Lastly, all infrastructure has a lifespan after which it becomes waste itself. Preliminary examples of lifecycle analysis already indicate that the environmental benefits can outweigh such trade-offs by a large margin. However, more knowledge is needed to better understand this balance, illustrated in general terms in Figure 3.

Figure 3. Environmental effects of digitalisation in the waste sector



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