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CONSTRUCTION AND DEMOLITION WASTE BEST MANAGEMENT PRACTICES IN EUROPE – BENCH-MARKING ANALYSIS. DIGITAL TOOLS

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Construction and demolition waste forms a significant percentage of all the waste streams generated in Europe. The European Commission has set targets and goals for this waste stream, implying the executions of circular economy principles. This paper synthesizes best practices for the management of construction and demolition waste, taking into consideration Member States that meet or even exceed those targets; specific attention is paid to those where digital tools are implemented to support the construction and demolition waste management process. An overview of the construction waste management landscape in Bulgaria is made, pointing out the main obstacles to sustainable construction and demolition waste management and the challenges of developing and launching a digital tool for optimization of the waste management processes and practices in a Eastern European country.

Keywords: construction and demolition waste; Europe; circular economy; digital tool

LAS MEJORES PRÁCTICAS DE GESTIÓN DE RESIDUOS DE CONSTRUCCIÓN Y DEMOLICIÓN EN EUROPA: ANÁLISIS COMPARATIVO. HERRAMIENTAS DIGITALES

Los residuos de construcción y demolición constituyen un porcentaje significativo de todos los flujos de residuos generados en Europa. La Comisión Europea ha establecido objetivos y metas para este flujo de residuos, lo que implica la ejecución de los principios de la economía circular. Este documento sintetiza las mejores prácticas para la gestión de los residuos de construcción y demolición, teniendo en cuenta los Estados miembros que cumplen o incluso superan esos objetivos; Se presta especial atención a aquellos donde se implementan herramientas digitales para apoyar el proceso de gestión de residuos de construcción y demolición. Se realiza una descripción general del panorama de gestión de residuos de construcción en Bulgaria, señalando los principales obstáculos para la gestión sostenible de residuos de construcción y demolición y los desafíos de desarrollar y lanzar una herramienta digital para la optimización de los procesos y prácticas de gestión de residuos en un país de Europa del Este.

Palabras clave: residuos de construcción y demolición; Europa; economía circular; herramienta digital

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1. Introduction

Not surprisingly, the 36 OECD (The Organisation for Economic Co-operation and Development) Member States, predominantly in Western Europe and North America, are responsible for generating and disposing of more waste than all other countries in the world, brought together. China is an exception, as the economic giant is likely to surpass this record and generate more than half of the world's waste by 2025. As Hebel, Wisniweska and Heisel (2014), in their introduction to the book *Building from Waste*, point out two possible trends for the future of this waste, including CDW:

1. Either to continue in the spirit of a modern linear economy, and economically developed countries continue to dump more unusable waste.
2. Or to take a new view that it is precisely these countries that have the opportunity to benefit from the rich resource that this waste provides them with

2. Best CDW management practices in EU member states. Digital tools

A number of countries in Western Europe and the United States have already made their first steps towards the second long-term and more sustainable solution. Innovative, sustainable practices, such as urban mining, are gaining ground in architectural solutions in these countries. The concept of the urban mining process is that most construction materials are no longer in their natural form in nature but are integrated and concentrated in the urban environment. For example, the content of copper as a raw material in traditional mines is decreasing, while its concentration in the composition of modern buildings is increasing, which suggests that in the future new mines will actually be the buildings themselves.

Similarly, concrete, which is the world's most used building material, can be recycled and re-invested in the construction of future buildings, which will not only reduce the release of additional CO₂ into the environment, but this recycled aggregate will show the same properties such as strength and resistance as newly cast concrete (Hebel, Wisniweska and Heisel, 2014). But these studies point first to the need to change the attitude of architects, designers and builders, who still predominantly draw on outdated ideas, methods and technologies from the industrialization era, rather than look to the future of more environmentally sustainable cities that they follow the pattern of circulating metabolism, or the idea that these new cities will constantly produce the materials they need without continuing to exploit and deplete natural resources.

At the same time, the advent of digital technology in this process is also inevitable in the name of optimizing the management of CDW. Digitization and robotics in the construction sector point to the future solution to a number of problems in developed countries where the recovery of construction waste is expected to become part of a more circular and sustainable economic system. In practice, digitalization provides new opportunities for productivity gains, helps optimize data management, especially in tracing building materials, and provides methods for sharing that data as well as for optimizing maintenance (Enkvist and Klevnäs, 2018).

For example, the introduction of the so-called "material passports" is precisely this type of innovative and digitized approach. These passports are documents that can be in paper and (preferably) in electronic form, summarizing the type, composition, quantity and use of construction materials in a finished product (building) or in the construction stage. In this way, the availability and continuous updating of the information in these passports makes it easier to monitor the building materials themselves, whether in the construction or demolition stages, and

helps to anticipate and use their future use or recycling more comprehensively (Wahlström, Bergmans, Teittinen, Bachér, Smeets and Paduart, 2020).

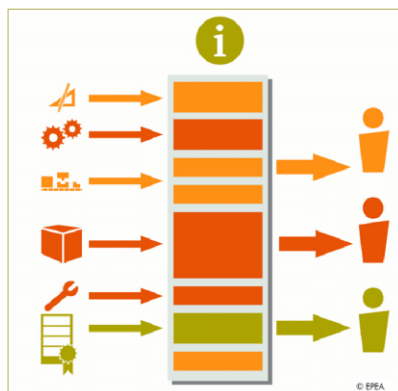


FIG. 2. Schematic presentation of the process of collecting data from different sources and forwarding the information to different participants in the construction process. Source: EPEA. <https://www.bamb2020.eu/topics/materials-passports/>

For example, more and more EU Member States are introducing material passports, which in the future is expected to help create a common, integrated market for second-hand building materials. BAMB (Buildings as Material Banks) is one such project that is EU funded and involves 15 partners from 7 Member States working together to create a circular business model economy in the construction sector, and in particular with regard to the process of incorporation, demolition, recycling and reuse of CDW (Luscuere, 2016). BAMB is an electronic system that also includes a database of over 300 'Material Passports' to reduce discarded CDW and to put them into future construction sites.


Materials Passport Platform Prototype				
Products Buildings Instances ? Logout				
 + Add Product	Products <input type="text" value="Search"/>			
	Name	Brand Name	Manufacturer	GTIN/EAN
	Accoya® Wood	Accsys Technologies	Accsys Technologies	Unknown
	Acrovyn® 4000	Acrovyn® 4000	Construction Specialties Inc.	Unknown
	Ahrend Balance Desk	Ahrend	Ahrend	Unknown
	AirMaster®	Desso	Tarkett	Unknown
	Aluminium Door Furniture	AMI BV	AMI bv	Unknown
	Armstrong Ultima+	Armstrong	Armstrong World Industries Limited	0888264102735
	Axia 2.0 Office Chair	BMA Ergonomics	Flokk	

FIG. 4. Example design of a prototype system for material passports. Source: BAMB. <https://www.bamb2020.eu/topics/materials-passports/>

Such a useful initiative, which is also gaining momentum in many Member States located in Western Europe, is the emergence and encouragement of the implementation of green public procurement in the construction sector. "Green" means contracts that include requirements for a certain percentage of "sustainable" materials to be used in the final project. In this way, project participants who rely more on environmentally friendly and sustainable ideas, methods and

materials are encouraged and more likely to win the contract. For example, in Italy there is Decree 205/2010, which states that the use of recycled materials is not only strategically important for the tender but is also a mandatory requirement. The proposed project should include the use of secondhand materials equal to at least 15% by weight relative to the total weight of all proposed materials (including 5% in the number of non-structural materials) (Giorgi, Lavagna and Campioli, 2018). Thus, Italy relies on the strength of legislative measures unlike some of the other major EU countries, which prefer to introduce freer measures of another nature as an audit report before the demolition of a particular site (pre-demolition audit) or the requirement of withdrawal and possession of a demolition license (Giorgi, Lavagna and Campioli, 2018).

At national level, a number of EU Member States can be cited as examples of good practices and the already initiated use of both recycling and reuse of CDW and the innovative introduction of digital solutions in this process. For example, Belgium stands out as one of the most appropriate examples of drawing on ideas about the management of CDW. The three major regions of the country have implemented a policy of governance autonomous from the federal (although the federal government has retained limited responsibility for some specific areas) and are not required to harmonize legislative requirements and practices with each other (Deloitte, 2015). Despite their relative independence, all three regions implement and comply with the relevant European directives, and their internal legislative strategy is remarkably similar. The main advantages of the Belgian approach lie in the constant adaptation of legislation with regards to changing factors and conditions, as well as in the concept of a holistic approach to the whole process of managing CDW, focusing not only on the stage of destruction but also on the prevention stage of creating more CDW during the design of the building. At the same time, the digitalization of this process is evident in the approach of one of the three regions, Brussels and the surrounding area, where one of the key tools for managing CDW is the Opalis website, which enables and facilitates communication between participants in the construction and after-construction process in order to encourage the re-use of CDW in construction and renovation activities.

Also, the Netherlands is doing extremely well in meeting the targets of the European Directive, reaching a recycling rate of CO between 90-95%. Governments aim the Dutch economy to fully embrace the circular model by 2050, with the program announced in 2016 focusing on the construction sector as one of the key priorities for the country in the future (Oorsprong, 2018). The country's approach can be described as more inclusive than other EU member states that are trying to increase their recycling rates for all waste and in particular CDW, and involves the government, representatives of the construction industry and many other interested organizations in the process of negotiating and developing a CDW reduction and recycling program (Oorsprong, 2018). The involvement of the private sector in government initiatives is just one example of the good practices that the Netherlands has put in place and implemented for years, with the idea of optimizing the most important industries not just through government intervention and control. In practice, in this way, government and legislative initiatives and goals are subject to a constant process of correction and improvement thanks to the hearing and acceptance of advice, problems and desires of private companies. A particular example of a government-private partnership that is beneficial to both countries is the Madaster platform, created by Thomas Rau, a radical architect, entrepreneur and visionary in the Netherlands. Like BAMB, Madaster aims to provide a common platform, in this case for companies and all types of legal entities as well as for individuals who have committed themselves to the design and / or construction of their home or ordinary private property owners (Madaster, 2020). The platform is in the form of a publicly

accessible, online database of building materials, facilitating the registration, organization, storage and exchange of information on these materials.



FIG. 4. Urban mine for materials. A screenshot of the Madaster platform. Source: <http://nest-umar.net/portfolio/material-cadastre/>

Although Germany has been lagging behind in terms of recycled CDW since the 1990s, the country is still experiencing rapid growth in the recent years, relying mainly on research (R&D) sponsored by a number of government institutions and involving a large number of organizations in total cooperation. Germany focuses on research to find innovative solutions to national and societal problems and needs, spending more than 3% of its GDP (equivalent to € 92.2 billion) in 2016 alone (GTAI, 2018). The state encourages and sponsors finding innovative solutions and models, including in the construction sector, which is one of the most demanding industries for the use of raw materials. In particular, the results of a three-year investment project led by the Fraunhofer Institute worth EUR 3.3 million identified plenty of CDW as aerated concrete that could be reinvested in future buildings (GTAI, 2018). The Institute, in collaboration with several other organizations, has introduced the so-called BauCycle process, which allows the reuse of certain CDW in high quality building materials. This is better known under the English term 'upcycling', or the transformation of a waste product for different uses, which must be distinguished from recycling, which necessitates the disposal and processing of the waste product itself in a raw material for reuse which is the same as the original one. For example, fine-grained materials, which represent 12.5% of the needs of the German sand and gravel construction sector, have previously been dumped in landfills or used in road construction or repair projects. Instead, the new project proposes the use of these fine-grained materials in high-quality aerated concrete, which can be used in the construction of two-story houses or in the form of insulation material. (GTAI, 2018). The project's designers also set out to create a dynamic online platform where raw materials can be sold and bought like any other product (GTAI, 2018). One of the reasons for this innovative initiative is the newly introduced regulations from the National Waste Association, which defines the upper limit for CDW (Weil, Jeske and Schebek, 2006). The impact of this change is expected to alter the existing open-ended use of CDW as sand and gravel mainly for roads or their disposal at CDW landfills. On the contrary, participants in the CDW management process need to look for new methods to deal with the stricter environmental regulations imposed

by the legislative framework, and the project mentioned above is one example of optimizing the management process of CDW, as well as a way to help create a circular economy (Weil, Jeske and Schebek, 2006). Thus, despite stricter regulation and the need to comply with environmental standards, the German example shows no conflict between legislation and the business sector, but rather offers a model of cooperation between the two for the sake of common goals and benefits. One such initiative that embodies this model is the hugely important 'Sustainable Building Certificate' issued by the German Sustainable Construction Union (DGNB), as well as the optional but recommended requirement for the inclusion of recycled building materials in public procurement, issued by a number of municipalities (Giorgi, Lavagna and Campioli, 2018).

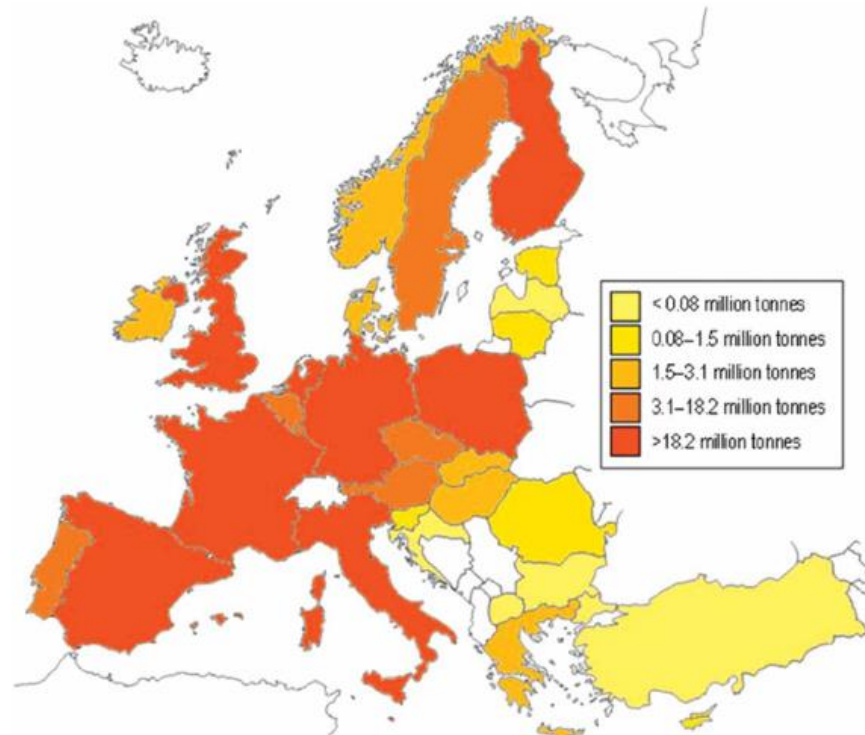


FIG. 5. Map of EU countries and the amount of CDW they generate annually (the largest sources are England, Belgium, Germany, Spain, Italy, Netherlands, Finland and France). Source: https://www.researchgate.net/publication/265734696_Overview_regarding_construction_and_demolition_waste_in_Spain#pfb

Not all countries in Western Europe have reached the achievements of countries such as Belgium and the Netherlands, but in recent years even those that are just catching up can be cited as an appropriate example for Bulgaria. One of these countries is Spain, which is also one of the main sources of CDW, with nearly 60% of those CDW being mass-produced in illegal landfills until recently (Rodríguez-Robles, García-González, Juan-Valdés, Morán-del Pozo and Guerra-Romero, 2015). However, since 2008, increased awareness of both Spanish politicians and the Spanish public has contributed to the creation of new legal frameworks and regulations aimed at reducing the environmental footprint of most industries, including the construction sector (Rodríguez-Robles, García-González, Juan-Valdés, Morán-del Pozo and Guerra-Romero, 2015). According to studies in this regard, however, these regulations are not sufficiently rigorous and lack adequate controls on implementation, which is also one of the similarities between Spain and Bulgaria in this area (Rodríguez-Robles, García-González, Juan-Valdés, Morán-del Pozo and

Guerra-Romero, 2015). According to the findings of the same study, the technology of treatment and recycling of CDW itself is sufficiently simplified and does not present a real challenge, but the problems that the country has to tackle are different administrative factors and processes, the lack of long-term and fruitful cooperation between the competent state authorities, agencies and institutions and businesses, as well as the lack of desire to put management and control measures into practice. Also, the problems of creating a public market for CDW and, with priority, the need to persuade designers, architects and builders to use these products, along with the need for the state to help create more opportunities for the use of recycled aggregates and other materials. Again, a number of similar characteristics between the two countries can be mentioned here, but the main difference is the practical superiority and prioritization that Spain increasingly attributes to the CDW management process. In other words, increased awareness of the state, regional governments, the scientific community and the construction sector itself are increasingly contributing to finding new and innovative solutions to current problems and pushing their efforts together for common goals.

Comparative studies point not only to the Western model as a source of good practice. For example, the study by Zheng and Li (2006) on the system and methods of construction waste management in Hong Kong also reveals the benefits of implementing an electronic system. The online trading platform, called Webfill, has been used as an innovative simulation that enables the online search for and trading of construction and demolition waste, thereby linking contracting entities, designers, builders, demolition executors, CDW processors and owners of construction waste landfills and optimizes the overall process and in particular helps to reduce the amount of construction waste. Although the program itself has not yet been put into direct use by participants in Hong Kong's CDW management process, the study's authors recommend implementing a similar simulation-based model to match business survey results such as SWOT analysis. However, in such rapidly developing countries as China and India, which are also among the largest pollutants and where the current target for CDW recovery is extremely low, more comprehensive legislative and practical frameworks are needed and, above all, a state initiative that is still lacking (Akhtar and Sarmah, 2018). In fact, the lack of a standardized system for evaluating the value and quality of CDW is a major obstacle to the wider utilization of this waste in future projects, which could be prevented through a more skillful and practical public policy to raise awareness of smart using those CDW (Akhtar and Sarmah, 2018).

While reviewing the contemporary framework of CDW management in EU countries, a number of leaders in the reuse and recycling of CDW countries such as Belgium, the Netherlands, can be identified. So far, twenty Member States have announced the achieved target of 70% of utilized CDW, which is a pan-European, although non-binding, target for this 2020. Given that in the waste category, CDW represents the largest flow in the EU, this is an extremely positive statistical conclusion (European Commission, 2018). However, it should be remembered that this 70% target also includes the so-called backfilling practice, which by itself does not contribute to the development of a circular economy and there also are extremely large differences between targets achieved by different Member States (European Commission, 2018). Thus, Bulgaria is moving closer to countries like China in its CDW management process than to EU leaders in this regard. Both China and Bulgaria lack a more targeted state initiative and policy.

3. CDW management in Bulgaria - overview

The building sector represents an important economic activity in Bulgaria. The management of CDW in Bulgaria involves a wide range of actors from the public and private spheres. A National Waste Management Plan for the time period 2014 – 2020 is in place in Bulgaria, dealing with general waste management action plans. It includes a presentation of the status of waste

management in Bulgaria, its opportunities, problems and objectives. Furthermore, it presents several programs for achieving established targets and optimizing waste management in Bulgaria through action plans. One of these programs addresses CDW specifically: “Program to achieve the targets for recycling and recovery of construction and demolition waste”. The action plans have different outcomes such as update of legal texts, use of recycled materials in specific type of constructions and creation of standards and requirements for certifications in the building sector.

For the construction and demolitions waste the ‘polluter pays’ principle is adopted. According to the Waste Management Act, the contracting entity commissioning construction and works with the exception of regular maintenance, and the contracting entity commissioning the removal of construction works shall draw up a Plan for management of construction and demolition waste. The Plan for management of construction and demolition waste has to be drawn up with the scope and contents laid down in the Ordinance on construction and demolition waste and use of recycled building materials.

In the Waste Management Act there are three national targets for re-use, recycling and other recovery of materials, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste, with the exception excavated soil, land and rock in their natural state which do not contain hazardous substances, shall apply, as follows:

1. no later than 1 January 2016 - as a minimum 35 per cent of the total weight of waste;
2. no later than 1 January 2018 - as a minimum 55 per cent of the total weight of waste;
3. no later than 1 January 2020 - as a minimum 70 per cent of the total weight of waste.

The obligations for proper management of CDW have been introduced only recently and therefore the sector is still at a stage of implementation and development of measures to reach the required goals.

The distribution and coverage of recyclers appears to be too low:

- Quantities of available CDW: although not enough quantities are available for recycling because of a lack of adequate practices, the capacity of existing facilities would not be enough according to experts and are deemed inadequate to deal with an increase of demand;
- National coverage of recycling facilities is too low: in Bulgaria it is estimated that CDW producers would not go further than 50 km to deposit their waste. As of first quarter of 2015, 22 recycling platforms were authorized in Bulgaria of which 6 in the region of Burgas, on the coastal line as being the most active in terms of construction due to tourism infrastructure development. Projects are undergoing for development of more facilities, but it seems rather slow (+7 facilities in the last two years) compared to the expected goals in the 5 years to come.
- Recycled products supply and demand do not meet to create a substantial solution for CDW recyclers and recycled material users:
 - The demand of recycled products is still very low, if non-existent, apart from the fulfilment of green procurement for public projects requirements.
 - The available recycled materials range is restricted as volumes do not create a financial advantage for the recyclers to broaden the supply (Deloitte, 2015).

So far small steps have been taken to introduce innovative waste management solutions in Bulgaria, such as public registers with the EEA (Executive Environment Agency), including Register of persons holding documents for performing waste activities. Another example is

Bulgaria's participation in the international project S.W.A.N. (a digital Solid Waste reuse pLAtform for BalkaN) in partnership with other Balkan countries - Greece, Albania and Cyprus. The project aims to develop a digital solution that will play the role of a facilitator in the development of sustainable business models in the Balkan region, providing detailed mapping of sources of solid waste and potential receivers, as well as an assessment of the economic feasibility of all symbiotic schemes in the region.

4. Final remarks

Observations made during this research show that the EU member states that meet and even exceed the set targets and goals for CDW stream, implying the executions of circular economy principles, already rely on complex digital solution, covering different aspects of CDW management process. Bulgaria itself has made first steps towards digitization of some areas of the process, mostly part of specific government activities.

Yet, the circular economy in the construction sector in Bulgaria also requires the introduction of up-to-date digital solutions to facilitate relations between actors, control and distribution of responsibilities, support rapid decision making and simplify construction waste documentation. In this way, it is also possible to reduce costs, to conserve natural resources and to reduce the environmental footprint of construction. Digital platforms that cover the whole process of CDW management, or essential parts of this process, are a similar tool. By digitizing CDW management processes, greater traceability of recycled materials can be achieved, leading to increased confidence in them. Research shows that from the good practices implemented in other EU Member States, Bulgaria could adopt both skillful government initiatives and useful business decisions. The author believes that the first stages of the construction management process to adopt digital solutions would ideally cover the design part of the project (where estimated waste amounts are digitally calculated based on the project characteristics) and also the trading sector, linking all recycled building materials' producers, which will eventually aim to increase awareness of their products and provide incentives for their clients. Future studies of the author will be directed precisely towards those two solutions.

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