Advanced Logistic Systems – Theory and Practice, Vol. 15, No. 1 (2021), pp. 5-11.
https://doi.org/10.32971/als.2021.001

S-BIN – SMART BIN DESIGN AND IMPLEMENTATION

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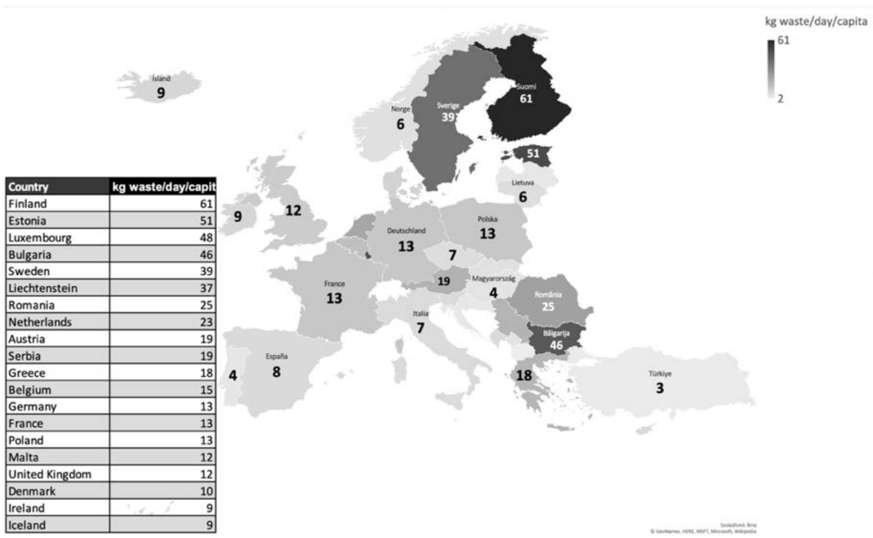
Abstract: Nowadays, the increase in consumption and the shortening of the life cycle of products significantly increase the amount of waste generated, causing serious environmental problems. As a result, waste management has become one of the most important tasks of the 21st century, which puts a huge burden on the economy. Waste management means the practical implementation of the protection of the environment from the harmful effects of waste on the entire life cycle of the waste. This is a process that involves the prevention, reduction, separate collection and utilization of waste generated, the temporary storage and disposal of non-recoverable waste without pollution. It follows from the above that logistics functions and services are playing an increasingly important role in waste management. In this paper, we use the example of a smart waste bin to show how smart technologies can be applied in the design of a waste bin.
Keywords: Industry 4.0, smart bin, reverse logistics, optimization

1. INTRODUCTION

As a result of social and economic development, much − and many types − of waste are generated, the recycling and handling of which is a global problem that affects us all. Improperly treated or stored waste can cause severe environmental damage, decrease water, soil and air quality, and can cause serious illness [1].



Country	kg waste/day/capit
Finland	61
Estonia	51
Luxembourg	48
Bulgaria	46
Sweden	39
Liechtenstein	37
Romania	25
Netherlands	23
Austria	19
Serbia	19
Greece	18
Belgium	15
Germany	13
France	13
Poland	13
Malta	12
United Kingdom	12
Denmark	10
Ireland	9
Iceland	9

Figure 1. Generation of waste (hazardousness and NACE Rev. 2 activity) per capita, 2016.

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Rational management of resources is one of the most important foundations of sustainable development. Selective waste collection and recycling are of the utmost importance as waste can be an important source of raw materials and energy.

Logistics (e.g. waste collection) is also a priority in waste management. Modern waste collection can be supported by various elements of the Industry 4.0 concept. By exploiting the benefits of digitalization, big data, digital twin solutions, and automatic systems with sensors can be developed. These solutions help increase efficiency and flexibility while reducing costs [2].

We can use smart containers, various wireless communication solutions, self-guiding vehicles to collect waste, so an integrated system can be developed.

2. Literature overview

2.1. Methodology

After determining the research question, we use keyword matching as the most common method for identifying literature after determining the relevant database(s) associated with it. The main theme can be selected by reviewing article summaries and reducing the number of resources. After selecting the methodology for analyzing the articles, the less researched areas and bottlenecks can be mapped after summarizing the main scientific results [3].

Among the potential databases (Google Scholar, ResearchGate, Science Direct, Scopus, Web of Science, etc.) we chose Web of Science. The focus of the search was on the terms "waste management", "reverse logistics", "Industry 4.0", "optimization" and "scheduling" and combinations of these. Figure 2 shows the number of publications published between 2005 and 2021.

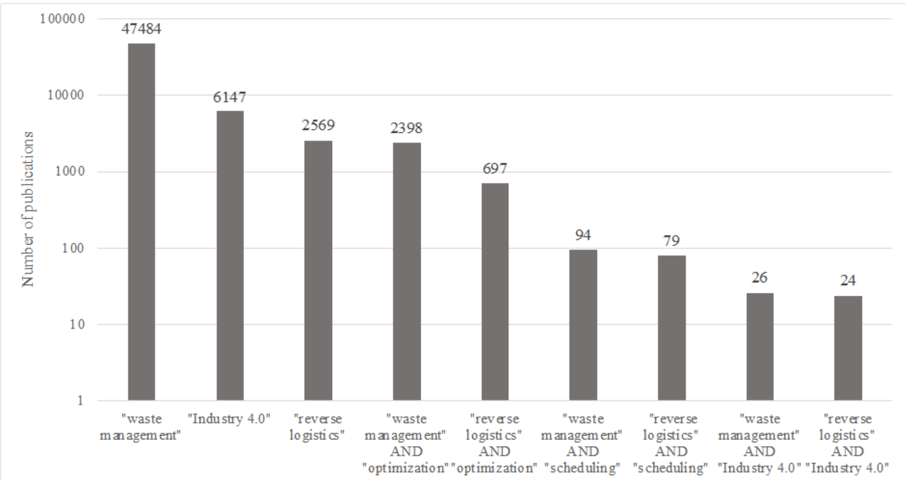

Figure 2. The number of published publications

A significant proportion of articles published in the subject area were written in the last five years. The number of publications published each year increases exponentially, which underlines the growing importance of the topic (Figure 3).

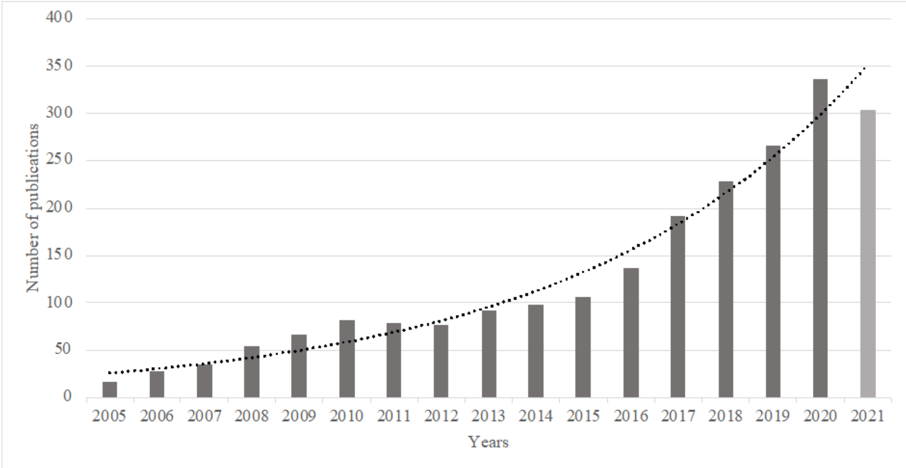

Figure 3. Number of publications in "waste management" and "optimization" broken down by year.

Based on the study of the literature, we have defined the research area and determined that the reverse logistics system using the Industry 4.0 technology and the development of a smart waste collection system based on these principles are the subject of our research.

2.2 Smart wastebin solutions

There have been a lot of clever bin developments in the last few years. One such solution is presented in a study by the Institute of Logistics at the University of Miskolc [4]. In the following we present some smart waste bins.

Smartup Cities [5]: Smart waste containers equipped with charge level sensors and wirelessly connected detectors allow for accurate planning, reporting and optimisation. Smartup Cities, a French start-up, is developing solutions for fill level monitoring of smart bins and containers based on ultrasonic sensors. They provide full remote visibility over any type of container and help plan collection routes accordingly.

Ecube Labs [6]: Using waste compactor sensors, it reads the fill level of the waste container in real time and then starts automatic compaction. This increases the capacity of the bin by up to 5-8 times. Ecube Labs, a South Korean start-up, has developed CleanCUBE - a solar-powered waste compactor that can hold up to 8 times more waste than non-compacting bins. A built-in safety sensor detects movement and stops waste compaction if a hand or finger is detected, while also reducing the frequency of collection.

Smartsensor [7]: During the filling level measurement, the built-in sensors also measure the current temperature inside the tank and transmit this information to the server together with other measured data. In case of sudden temperature changes (e.g. fire), the system automatically informs the operators by text or e-mail alerts. The Australian based Smartsensor monitors the fullness and temperature level of each bin and provides maintenance alerts at the request of customers.

EvoEco [8]: Innovative bins are equipped with screens, displays or other interactive systems to keep users' attention. For example, they can teach users how to sort waste correctly or motivate them every time they throw their rubbish in the bins. The US-based company EvoEco has developed EvoBin, which displays messages to the user, triggered by internal sensors and depending on the type of waste being thrown away. Messages can be tailored to specific audiences or events.

Sensoneo [9]: Intelligent route planning allows automated management of waste collection routes based on precise, predefined analytical data on the condition of waste collection vehicles, container placement and filling level. The Slovak company Sensoneo combines ultrasonic sensors (Single, Double, Quatro and Micro sensors) that monitor waste in real time with sophisticated software (Smart Analytics, Smart Route Planning and Smart Waste Management System) to provide cities with data-driven decisions to optimise waste collection routes, frequencies and vehicle loads.

3. DESIGN AND CONSTRUCTION OF A SMART WASTEBIN

The idea for the S-BIN smart bin was inspired by the real world. In many areas (e.g. holiday areas), municipal waste is not collected all year round, but only seasonally. As a result, the responsibility of storing and disposing of the waste generated during this period falls on property owners. The smart waste collector we are designed would address this issue and allow for communal use of waste containers, where members of a community deposit their small amounts of waste in a larger communal container (shared economy). Members would pay the costs of waste transport in proportion to their use.

Figure 4. S-BIN

If you're going to have a bin, then have a smart bin, that was the basic concept. On the one hand, this manifests itself on the user side, as the device can be used after QR code or RFID-based identification, and on the other hand, thanks to the built-in sensors, the company responsible for waste disposal can monitor the use and fullness of the containers.

The smart bin we have designed has a capacity of 1100 litres, making it suitable for the simultaneous storage of approximately 35 bin bags with a capacity of 30 litres. It is of course possible to build a larger unit, but it would be difficult to store and transport more than this in the present development phase.

Power for operation is also provided by a solar panel and/or battery.

Sensors are placed inside the container to measure the fill level, and the current fill level can be monitored on a dashboard on the outside of the container. Status indicators indicating operation, successful or unsuccessful communication are also placed on the same dashboard.

A microcontroller and a minicomputer (e.g. raspberry pi) are used as the central unit.

Communication with the outside world is provided by WIFI or mobile internet.

A small display is also built into the prototype bin to provide information on the usage of S-BIN.

Users have a unique profile and balance. After registering and paying the fees, users will receive an NFC bracelet, key fob, or plastic card. After logging in, they can track their used credits and top up their balance here. A web interface is used to display the data.

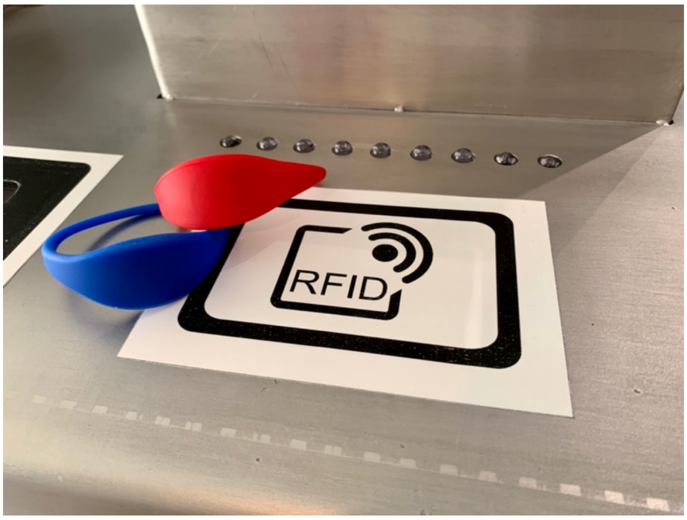

Figure 5. RFID identification

The container is basically sealed and only after authentication (RFID/NFC) is it possible to put the waste in using an adapter designed for this purpose.

Using our mobile phone, we can scan the QR code (the LEDs will turn blue) and then identify ourselves by entering our username and password.

If we have enough credits, you can start using the equipment. A green LED light shows us which hatch we can use, and which lid can be opened.

Figure 6. S-BIN - ready to use

Then we put the bin bag in and close the lid. The bag then falls into the bin as a result of a horizontal flap being launched. A flashing green light warns you that the lid is open.

You can also identify yourself with an RFID bracelet, for example, without the need for a mobile phone. We just touch the bracelet to the built-in reader and we can use S-BIN.

An extra feature is the mini weather station, currently available online with temperature and humidity data.

Figure 7. Temperature and humidity information available online

When it is time to empty the bin, the bin is pulled out of the metal structure, the identification is contactless, using RFID technology, and after successful authentication, the doors can be opened, which is shown by the LEDs on the bin. After emptying, the returned bin is detected by sensors and the doors are closed.

For many service providers, the problem is that they do not have any information on the level of fullness of the bins placed in public areas, so they empty each bin every time, with no possibility to optimise the collection schedule of the routes. It will therefore be worthwhile to look into the development of similar containers with a much smaller capacity than the S-BIN and, for reasons of economies of scale, a much larger capacity.

3. Summary

The Institute of Logistics of the University of Miskolc was one of the first to be involved in the research of the logistics aspects of Industry 4.0. This is indicated by the number of publications produced by the Institute's staff over the past few years. The paper presents a smart bin solution that also implements Industry 4.0 principles.

Acknowledgements

My work as a member of my research group was supported by Dr Péter Tamás, Associate Professor and Director of the Institute of Logistics, and I received a lot of help from the Technology and Knowledge Transfer Directorate coordinating the Proof of Concept project. I had several consultations on waste management issues and received useful advice from Roland Ladányi, Managing Director of the Miskolc Regional Waste Management Ltd, and they also provided the dustbin for the project, the metal structure was made by the staff of KEVIÉP in Debrecen, I would like to highlight Ferenc Nagy, who gave me many good ideas, in the IT and electronics design and implementation I could rely on the staff of our family company, ZL Rendszerház Kft, Zoltán Besse and Márk Nagy.

References

[1] Kaza et al. (2018). What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. *Urban Development*. Washington, World Bank. https://openknowledge.worldbank.org /handle/10986/30317 License: CC BY 3.0 IGO. https://doi.org/10.1596/978-1-4648-1329-0_ch2

[2] Glistau, E. & Machado, N. I. C. (2018). Industry 4.0, Logistics 4.0 and Materials - Chances and Solutions. *Materials Science Forum* **919**. 307-314. https://doi.org/10.4028/www.scientific.net/MSF.919.307

[3] Zhang, L. & Liu, W. (2017). Precision glass molding: Toward an optimal fabrication of optical lenses. *Frontiers of Mechanical Engineering*. **12**(1) 3–17. https://doi.org/10.1007/s11465-017-0408-3

[4] Cservenák, Á. & Bányai, T. (2020). Smartbin development for cyber-physical waste collection, In: *Proceedings of the 13th International Doctoral Students Workshop on Logistics*, Otto-von-Guericke-Universität Magdeburg, 45-48.

[5] *Smart Waste Management Solutions*, https://www.smartupcities.com/

[6] *CleanCUBE, the solar-powered trash compactor*, https://www.ecubelabs.com/solar-powered-trash-compactor/

[7] *Smartsensor®*, https://www.solarbins.com.au/smartsensor/

[8] *The Evo Bin*, https://evoeco.com/