UDK 338.121:658.567]:657.471:004(497.7)
628.4:005.963.5]:657.471:004(497.7)
Original scientific paper

NEDA PETROSKA-ANGELOVSKA[*]
MILENA BOSHKOSKA KLISAROSKI[**]
TEA JOSIMOVSKA[***]
NATASHA BOGDANOVSKA[****]

THE ROLE OF ACCOUNTING INFORMATION SYSTEMS IN SUPPORTING CIRCULAR ECONOMY GOALS: A CASE STUDY OF WASTE COLLECTION AND COST MANAGEMENT IN THE REPUBLIC OF NORTH MACEDONIA

Abstract: *The paper explores the strategic role of Accounting Information Systems (AIS) in supporting circular economy (CE) goals, focusing on cost management and waste tracking in North Macedonia. Through a case study of Pakomak DOO Skopje, the research highlights how AIS enhances transparency, efficiency, and decision-making in packaging waste collection.*

The integration of AIS with CE practices enables precise cost allocation, environmental impact assessment, and legal compliance. Findings suggest that AIS, when aligned with digital technologies and sustainability strategies, serves as a key enabler for achieving long-term environmental and economic value in circular systems and sustainability.

Keywords: Circular economy, Accounting management system, Strategic cost management, Packing waste, Sustainability

[*] Full time professor, PhD, Institute of Economics – Skopje, Ss. Cyril and Methodius University in Skopje, Republic of North Macedonia, e-mail: neda@ek-inst.ukim.edu.mk

[**] Assistant professor, PhD, Institute of Economics – Skopje, Ss. Cyril and Methodius University in Skopje, Republic of North Macedonia, e-mail: milena.boskoska-klisaroski@ekinst.ukim.edu.mk

[***] Assistant, MSc, Institute of Economics – Skopje, Ss. Cyril and Methodius University in Skopje, Republic of North Macedonia, e-mail: tea.josimovska@ek-inst.ukim.edu.mk

[****] Natasha Bogdanovska, Supervisor for accounting and finance, Pakomak DOO Skopje,

[*****] The research in this paper is related to the project: "Transition to a circular economy in the Republic of North Macedonia-opportunities and challenges", "Institute of Economics" – Skopje, funded by the integrative funds of "Ss. Cyril and Methodious" University in Skopje.

JEL Classifications: M41, Q56

INTRODUCTION

In response to increasing environmental concerns and stricter regulatory frameworks, the circular economy (CE) has become a vital pathway toward sustainable development. Unlike the traditional linear model of "take, make, dispose," the circular economy emphasizes reducing waste, improving resource efficiency, and extending product life cycles through reuse, recycling, and regeneration. As industries and governments move toward this model, the role of digital technologies, particularly Accounting Information Systems (AIS) is becoming increasingly important.

AIS, originally designed for financial reporting and internal control, are now evolving into tools that support broader strategic goals, including sustainability and circular practices. When adapted to the needs of the circular economy, AIS can deliver valuable insights through accurate and timely data on material flows, waste management, cost efficiency, and compliance with environmental regulations. Despite their potential, the integration of AIS with circular economy strategies remains a relatively underexplored area in both academic and practical contexts.

This paper investigates the implementation and role of AIS in achieving circular economy objectives, with a specific focus on waste collection and cost management. Using the case of Pakomak DOO Skopje, the primary collective waste operator in North Macedonia, the study explores how AIS enhances operational performance, monitors costs, and contributes to environmental outcomes.

The main research goal is to assess the contribution of AIS to CE targets through improved reporting, strategic cost management, and system optimization. Additional objectives include identifying system functionalities that support CE and proposing recommendations for future improvements.

1. INFORMATION SYSTEMS AND THE CIRCULAR ECONOMY INTEGRATION-THEORETICAL ASPECTS

Information systems play a crucial role in integrating with the CE by enabling efficient resource management, extending product lifecycles, and supporting sustainability. Theoretical aspects focus on how digital technolo-

gies and information systems empower CE practices by enhancing data flows, traceability, stakeholder collaboration, and operational processes across product lifecycles and supply chains. Actually, "the integration of digital technologies and CE principles synergistically contributes to sustainability, making it imperative for firms striving for long-term sustainability to adopt a comprehensive strategic approach that embraces both digital technologies and CE".[5]In addition "information systems (IS), being fed with appropriate data thanks to the support and the integration with Industry 4.0 technologies, can be useful for the fulfilment of sustainable and circular goals".[6] This integration is framed through multiple theories that address motivators, enablers, synergy, environmental context, and multi-level stakeholders, facilitating the shift towards sustainable production and consumption.

These systems enable strategies like reduce, reuse, recycle, remanufacture, and extend product life by optimizing resource use and reducing and proper collecting of waste. It is obvious that, "by adopting circular economy principles, organizations can greatly reduce their environmental impact, enhance resource efficiency, and generate long-term value while also mitigating issues such as climate change and greenhouse gas emissions. Essentially, sustainability is meeting present needs without compromising the ability of future generations to meet their own needs".[7] "As companies, governments, and communities increasingly acknowledge the advantages of this strategy, the circular economy will become a fundamental aspect of sustainable development, promoting economic expansion while protecting our planet for future generations."[8]

Continuously, economies should take into consideration the interplay between information systems and circular economy principles, guiding both research and practical adoption in order to achieve sustainable value creation and competitive advantage in all areas. In other words, "embedding information systems capabilities into organizational processes for transitioning to a circular economy model can present economic benefits depending upon the

[5] Soode V., Mahtab K., Dara S., Joseph S.: Digital Technologies and the Circular Economy: A Theoretical Perspective, Computers & Industrial Engeneering, Vol. 206, August 2025. (https://doi.org/10.1016/j.cie.2025.111225) .

[6] Doroteja V., Marjeta M., Andreja P.: Information Technology for Business Sustainability: A Literature Review with Automated Content Analysis, Sustainability, MDPI, vol. 13(3), January 2021. (RePEc:gam:jsusta:v:13:y:2021:i:3:p:1192-:d:485843).

[7] Purushothaman R., Alamelu R., Selvabaskar S., Sudha M.: Theories, techniques and strategies of sustainable circular economy: A systematic literature review, Discover Sustainability April 2025 6:297. (https://doi.org/10.1007/s43621-025-01161-5).

[8] Ibidem.

uncertainty within their specific operating environment."[9] Through this synergy, businesses and society can achieve greater competitiveness and sustainability by driving innovative and environmentally responsible solutions that create value and promote sustainable development.

2. ACCOUNTING INFORMATION SYSTEMS AS A TOOL FOR STRATEGIC COST MANAGEMENT

As a part of the information systems that can and should be related to implementation of circular economy is AIS of companies that serves as vital tools for strategic cost management. By providing timely, relevant, and accurate financial and operational data AIS enables organizations to analyze, control, and reduce costs effectively. From a scientific research perspective, AIS integrate accounting methods with information technology to support strategic decision-making, optimize value chains, and align cost management strategies with organizational goals."AISs are systems used to process data and transactions to provide users with the information needed for planning, controlling, and business operations. Therefore, high-quality information is very important, which means accurate and timely information. The role of accounting information systems in a company is very crucial and essential for management, because it provides financial reports that can be used to evaluate various business activities and assess the performance of each unit given authority and responsibility."[10]

From the strategic cost management point of view, AIS gives support in the processes of: evaluating all value-adding activities to identify cost advantages or inefficiencies and improve customer value delivery; deciding competitive approaches such as cost leadership or differentiation that guide cost management priorities and in cost driver analysis by understanding the factors that influence costs to optimize resource use proper, reduction and collection of waste.

Overall, AIS is conceived, not merely as transactional recorders but as strategic assets that provide a comprehensive data-driven foundation for

[9] Randy R., Carmen M. F., Jos´e L. R., Juan C. R.: Information systems capabilities value creation through circular economy practices in uncertain environments: A conditional mediation model, Journal of Business Research 175, 2024. (https://doi.org/10.1016/j.jbusres.2024.114526)

[10] Wardatun N., Muhammad N., Tri W., Chandra P.: The Role Of Accounting Information Systems In Improving Management Strategic Decision, MSR Journal, Vol 3 issue-3, 2024.

managing costs proactively and sustaining competitive advantage in dynamic business environments. This approach highlights the pivotal role of AIS in aligning accounting information flows with strategic objectives and enhancing organizational performance through effective cost management. AIS improves strategic cost management by automating data collection and processing, enabling real-time reporting, improving accuracy, and integrating financial data with other business operations. This leads to better analysis of costs over product life cycles, life-cycle costing, activity-based costing, and supports sustainability and quality cost management. AIS also plays a strategic role by aligning with overall business strategies, providing information for external competitive analysis, and supporting diversification and differentiation efforts. "Decision-makers can receive relevant information from AISs and utilize it in decision making and strategy development to help the firm accomplish its goals and objectives and improve its performance."[11] Moreover, AIS contributes to cost management by reducing operational costs through automation, improving interdepartmental collaboration, and safeguarding data integrity with internal controls. These improvements enhance profitability and efficiency, making AIS a critical tool for managing costs strategically in competitive environments.

3. AIS IMPLEMENTATION IN PAKOMAK DOO SKOPJE FOR WASTE COLLECTION COST TRACKING

3.1. Pakomak DOO: Organization and Role in Waste Management

Pakomak DOO is the first collective waste operator in North Macedonia, primarily engaged in the management of packaging and packaging waste (PW). Its mission is closely aligned with the principles of the circular economy, which emphasize minimizing waste and maximizing resource efficiency through the sorting, collection, and transportation of waste to authorized final handlers. Through its operations, the company reduces the negative impact of PW on the environment and promotes responsible corporate behavior in waste management, thereby contributing to a better quality of life and establishing a system in line with the principles of sustainable development.

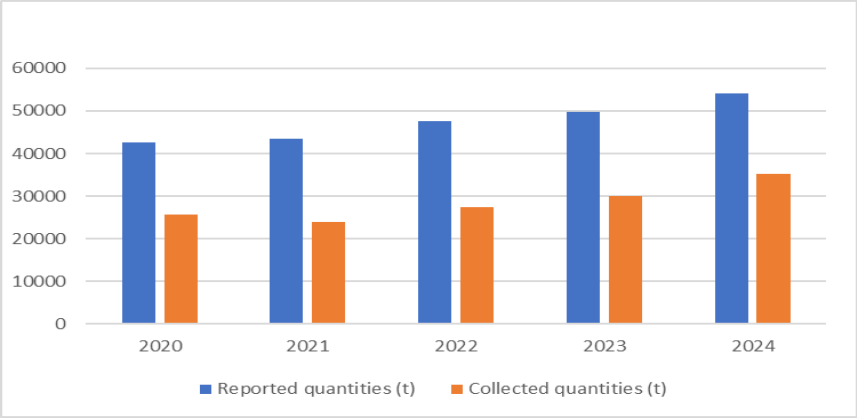
[11] Emad H., Ahmed Hussein R.: The Influence of Accounting Information Systems (AIS) on Performance of Small and Medium Enterprises (SMEs) in Iraq, Journal of Business & Management 3(4):48-57,2014
(DOI:10.12735/jbm.v3i4p48)

With the introduction of the Law on Packaging and Packaging Waste Management (LPPWM) in 2011, all producers[12] became responsible for the entire PW generated from the sale of their products on the territory of North Macedonia. In other words, their responsibility extends beyond the point of sale they are obliged to manage the waste resulting from the packaging of their products. Therefore, systems like Pakomak are also referred to as Extended Producer Responsibility (EPR) systems.These companies are required to register their PW under an EPR system and finance its collection based on the quantities of PW placed on the market, in accordance with the legally established annual collection targets.

In 2024, more than 790 companies reported their PW through Pakomak's system, delegating the responsibility to Pakomak to manage the PW that ends up on the market in the Republic of North Macedonia.Through collaboration with municipalities, the private sector, and citizens, Pakomak has been increasing the rate of proper sorting and collection of PW (Chart 1), year by year. This progress is an indicator of advancement toward a circular economy and long-term reduction of environmental impact, achieved through the following three main activities, in accordance with legal responsibilities: installing infrastructure for the separation of PW as part of municipal and industrial waste; organizing the collection of sorted PW from this infrastructure and from other appropriate collection channels; raising public awareness about the need for waste separation in general, with an emphasis on PW and the benefits for individuals and society, as a whole.

[12] Producers – manufacturers and importers who, along with their products, place packaging waste on the territory of the Republic of North Macedonia (in accordance with the Law on Extended Producer Responsibility for the Management of Specific Waste Streams).

Chart 1. Reported and Collected Quantities of PW by Pakomak for the Period 2020–2024 (in t)



Source: Annual Reports on the Operations of Pakomak for the Respective Years.

During the analyzed period, the company achieved positive results by continuously increasing the amounts of reported, properly sorted, and collected waste. In accordance with the LPPWM, Pakomak exceeded the nationally set targets. According to estimates by the Ministry of Environment and Physical Planning, the total amount of packaging waste generated in North Macedonia in 2025 will be approximately 116,029 t annually (Annex 6 – National Waste Management Programme 2021–2031). Pakomak is contracted to manage (collect and deliver for recycling) around 54,000 t of the above, or roughly 47%.

3.2. Functionalities and Application of AIS

To support and implement these goals, Pakomak uses a modern AIS Betako Soft, custom-designed for the needs of Pakomak. It is a key tool for ensuring financial transparency and operational efficiency in PW management processes. The system is designed to integrate financial and operational data, enabling precise tracking of costs by activity, geographic area, collection channel, type of packaging waste (paper, plastic, glass, cans, etc.), collecting company, and time period. It allows detailed monitoring of all transactions related to the company's activities. The system can also be easily adapted for other waste streams (e-waste, waste tires, used oils, textile waste).

Through this capability, the AIS generates reports that monitor overall operations. Operational reports demonstrate collection efficiency (by quantity and cost), the share of each type of sorted PW in the total collected amount,

and the efficiency of collection routes. This allows management to identify and improve operational segments in the most efficient way (Table 1).

Table 1. Collected PW by Category for the Period 2020–2024 (in t)

Year	Plastic (t)	Paper (t)	Metal-Fe (t)	Metal-Al (t)	Glass (t)	Wood (t)	Composite (t)	Total (t)
2024	5.637,528	19.236,129	2.068,48	232,802	6.172,843	1.803,977	0	**35.151,759**
2023	5.235,749	15.328,248	1.807,755	203,511	5.806,919	1.556,754	0	**29.938,936**
2022	5.021,992	15.718,727	684,426	182,369	5.121,083	792,266	0	**27.520,863**
2021	4.775,357	13.050,596	652,611	178,892	4.687,467	663,942	0	**24.008,865**
2020	4.194,971	16.124,214	800,207	68,815	3.778,821	793,88	0	**25.760,908**
Total (2020–2024)	**24.865,597**	**79.457,914**	**6.013,479**	**866,389**	**5.567,133**	**5.610,819**	**0**	**142.381,331**

Source: Annual Operations Report of Pakomak for the respective years

The table above clearly illustrates the practical use of the system in recording the separate quantities of packaging waste by category, collected on behalf of Pakomak's clients for the 2020–2024 period, in line with the LPPWM. It can be observed that during this period, the company shows a continuous annual increase in collected quantities. This is largely due to the availability of analytical data from the implemented AIS, which helps the company focus on the collection channels that can achieve the greatest increase in collected PW with reducing operational costs.

The presented results are in accordance with Article 21 of the LPPWM and the specified percentage targets per year and per type of PW, which must be collected by the collective waste operator relative to the amount of packaging placed on the market in North Macedonia. This, also aligns with the company's strategic plan to comply with legal regulations. The data are key business (KPI) and environmental indicators, as they signal which regions or collection points are the least or most efficient within the established collection system, and how the collection network should be adjusted. The continuous increase in collected PW is directly related to improved efficiency of the infrastructure in identified weak segments/regions/channels and optimizing the collection scheme, while also applying circular practices.

An overarching goal of all these activities is to generate the minimum possible carbon footprint from the collection and transport of PW. At the same time, the company strives to work with regional or local partners who collect the PW and deliver it to the nearest collection center. Moreover, the implemented AIS is crucial for detecting operational efficiency by activity. This is enabled through cost allocation by activity (collection channel, PW type,

region, collecting company) and ongoing comparison with the company's planned budget. (Table 2)

Table 2. Average Cost of Packaging Waste Collection 2020–2024

Collection costs by year			
Year	**Waste (t)**	**Total costs (den)**	**Average costs**
2024	35.151,59	78.102,074	**2.221,583**
2023	29.938,936	61.409,993	**2.000,929**
2022	27.520,863	47.957,440	**1.540,406**
2021	24.008,865	40.027,991	**1.658,93**
2020	25.760,908	37.861,156	**1.469,235**
Total (2020–2024)	**142.381,331**	**265.358,654**	**9.161,09**

Source: Annual Operations Report of Pakomak for the respective years

The cost analysis provides insight into and assessment of the system's economic efficiency over a given period and for specific PW types and collection channels. Table 2 illustrates how the AIS tracks the cost dynamics of waste collection by year, both in absolute terms and as average cost/t of collected packaging waste. Even though in 2024 there is a 51.6% increase in the average collection cost compared to 2020—which may seem illogical given the "economy of scale" principle (a 38% increase or 7% more PW was collected)—these outcomes were forecasted and expected thanks to the KPIs from the AIS. This is due to two main reasons: the share of waste fractions with the highest collection costs (glass, plastic, and aluminum) increased as required by the Ministry of Environment and Physical Planning and each additional ton collected requires more effort and cost, as the easier-to-collect quantities are already exhausted ("no low-hanging fruit").

In addition to costs by collected PW type as business indicators, the system also calculates: the fill-time of Reverse Vending Machines (RVMs) and containers, the number of users per RVM, the number of collected items per RVM and container location, etc. The AIS also enables the generation of environmental indicator reports, which provide analytical insights into the company's ecological efficiency and its contribution to the goals of the circular economy. These reports show the amount of PW sorted and delivered for further treatment, and therefore the direct savings of natural resources.

The indicator for collected PW quantities (especially glass) and kilometers traveled (KPI: km/ton) directly show the CO_2 emissions for a given activity. The number of RVM users and the amount of PW collected via RVMs are also key environmental indicators. The aim is to have the selection equipment

(containers, RVMs) as close to citizens as possible to motivate them to separate their waste.With this information, Pakomak can measure waste reduction through proper sorting and collection of PW, which serves as a relevant indicator of the success of circular practices.

The automation of processes allows the system to deliver accurate and timely data, minimize the risk of errors, improve forecasting and planning, and increase operational efficiency. Additionally, the system is designed to be flexible and able to adapt to changes in legislation, ensuring sustainability and continuous operational development in alignment with circular economy goals. In this way, the AIS not only supports the financial and operational efficiency of Pakomak but also provides critical insights for achieving the goals of the circular economy and the long-term transition of North Macedonia toward a sustainable economic model.

4. IMPLICATIONS AND RECOMMENDATIONS FOR ENHANCING AIS FOR CIRCULAR ECONOMY GOALS

The AIS is a crucial element and foundational component in modern PW management and company operations in general. Through data processing, storage, and analysis, this system enables timely and accurate information to be provided to management, directly influencing the ability to make high-quality strategic decisions. Its application ensures transparency, increased efficiency, improved control over all business processes, and alignment with both European and national standards.

In this regard, Pakomak serves as a positive example of how its accounting information system not only supports accurate and timely event tracking but also plays a broader role: facilitating planning, performance monitoring, legal compliance with PW management regulations, and serving as a key tool for strategic decision-making. This highlights the importance of continuous maintenance, upgrades, and adaptation of the system in line with changing company needs and external conditions.

To achieve higher results within the circular economy framework, there are opportunities for further enhancement of the system. The following recommendations address the technological, organizational, and regulatory aspects of the AIS:

- Continuous implementation of new generations of sensors on containers/infrastructure to obtain real-time data on the fill level of sorting containers and RVMs. This enables route optimization for collection.

One of the main drivers of the circular economy will be the Internet of Things (IoT), which is becoming more precise and affordable to implement.

- Introduction of digital tracking solutions for the flow of PW through integration into the AIS. The use of barcodes in the HORECA[1] channel and on RVMs, along with GPS technology, enables precise identification and monitoring of PW from the pickup point to the final handler. Integration of this data into the AIS increases transparency and reduces the risks of unverified or improper PW handling, as well as manipulation of legal and system obligations.
- Installation of solar panels on secondary PW sorting lines. In addition to the primary sorting done by citizens via the aforementioned infrastructure, secondary sorting is necessary to remove improperly sorted waste and further sort well-separated PW by type and color. If these sorting facilities are automated and of higher capacity, they require significant electricity, which can be partially or fully offset by installing efficient solar panels.
- Use of Artificial Intelligence (AI) to analyze large datasets for decision-making. The vast amount of data generated by the AIS can be processed with AI algorithms to identify patterns and trends, enabling managers to make faster and more informed decisions. Predictive analytics can help forecast future behavior or detect system irregularities.
- Inclusion of producers who are either not part of the EPR system or underreport the quantities of packaging placed on the market. This can be addressed through digital comparison of companies within the same industry, evaluating their market share versus their reported PW quantities. One of the biggest challenges remains the partial participation of producers and importers in the EPR system. Some companies are not included at all, while others report unrealistically low packaging quantities. It is estimated that at least 30% (over 30.000 t) of all PW placed on the market is not financed by any collective waste management system (apart from Pakomak, there are two smaller systems). This results in a shortfall of at least €1.2 million per year for the waste sorting and recycling systems. Proper participation would significantly accelerate the transition to a circular economy.

[1] HORECA- an international abbreviation commonly used for the sector: of hotels, restaurants, and cafés.

A possible solution is the development of a digital mechanism for comparing companies within the same industry. Using the AIS, a company's market share can be compared to its reported PW quantities. This would allow for the timely detection of irregularities, enabling more efficient control and fair obligations among all producers.

The implications and recommendations for the enhancement of the AIS, in line with circular economy principles, indicate that future development must be based on integration of digital technologies, automation via IT, and transparency. This feedback mechanism shows that the system should not just be a passive data repository, but rather an interactive tool for improving operations and achieving both corporate and circular economy goals.

CONCLUSION

The paper highlights the vital role of AIS in supporting CE goals through enhanced cost management, transparency, and operational efficiency. The case of Pakomak DOO Skopje demonstrates how AIS can be effectively utilized to monitor packaging waste collection, track costs, assess environmental impact, and ensure regulatory compliance. AIS, when integrated with digital tools and sustainability strategies, evolve from simple data processors into strategic systems that support informed decision-making and long-term value creation.

The findings underscore the need for continuous development of AIS functionalities, including automation, real-time data collection, and environmental reporting, to align more closely with CE principles. Strengthening this synergy is essential for accelerating the transition toward a sustainable and resource-efficient economic model in North Macedonia and beyond.

REFERENCES:

1 Doroteja V., Marjeta M., Andreja P., 2021. "Information Technology for Business Sustainability: A Literature Review with Automated Content Analysis," Sustainability, MDPI, vol. 13(3), January 2021. (RePEc:gam:jsusta:v:13:y:2021:i:3:p:1192-:d:485843).

2 Ivan S., Mihailo J., Sabahudin H.: "Information technology in the function of circular economy and sustainable development", Proceedings of the International Conference "Information Society and Sustainable Development, Varna Bugaria, ISSD 2024.

3 Purushothaman R., Alamelu R., Selvabaskar S., Sudha M.: "Theories, techniques and strategies of sustainable circular economy: A systematic literature review", Discover Sustainability April 2025 6:297. (https://doi.org/10.1007/s43621-025-01161-5).

4 Randy R., Carmen M. F., Jos´e L. R., Juan C. R.: "Information systems capabilities value creation through circular economy practices in uncertain environments: A conditional mediation model", Journal of Business Research 175, 2024. (https://doi.org/10.1016/j.jbusres.2024.114526).

5 Selim B., Yusuf K., **Çağrı** K., Durmuş S.: A New Cost Accounting Concept by the End of 20th Century: Strategic Cost Management, Adnan Menderes University, Turkey.

6 Soode V., Mahtab K., Dara S., Joseph S.: Digital Technologies and the Circular Economy: A Theoretical Perspective, Computers & Industrial Engeneering, Vol. 206, August 2025. (https://doi.org/10.1016/j.cie.2025.111225).

7 Wardatun N., Muhammad N., Tri W., Chandra P.: The Role Of Accounting Information Systems In Improving Management Strategic Decision, MSR Journal, Vol 3 issue-3, 2024.

8 Annual Reports on the Operations of Pakomak for 2020, 2021, 2022, 2023, and 2024, in accordance with the Law on Management of Packaging and Packaging Waste.

9 Law on Packaging and Packaging Waste Management (Official Gazette No. 215, dated September 16, 2021).

10 Law on Extended Producer Responsibility for Specific Waste Streams (Official Gazette No. 215, dated September 16, 2021)

11 Waste Management Plan of the Republic of North Macedonia 2021–2031, Annex 6 – National Programme for Packaging Waste Management.