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Circular economy and innovation: advancing technological solutions to reduce waste

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ABSTRACT

This paper explores the fundamental principles of the green and circular economy, emphasizing innovative approaches to waste management. The circular economy, rooted in sustainability, seeks to minimize environmental impact and optimize resource use. The text underscores the significance of technological advancements in waste reduction and explores various dimensions of innovation within the context of the innovation process. The innovation process is delineated through phases such as invention, development, and diffusion, with critical managerial activities highlighted. Special emphasis is placed on environmental innovation, particularly eco-innovations, which aim to achieve a positive impact on the environment coupled with economic benefits. The concept of environmental innovation is closely tied to sustainable development, and the paper outlines how organizations can contribute to sustainability through eco-innovation. Furthermore, the discussion extends to waste management, including stages such as prevention, recycling, and disposal. Innovative technological solutions in waste management, such as robotics and cloud computing, are highlighted, with a focus on their potential role in the future. Case studies of companies like E-Recycling in Serbia and Geocycle in Italy provide practical examples of effective waste management aligned with circular economy principles. In conclusion, the paper underscores the critical role of innovation and technological solutions in advancing the circular economy and fostering sustainable waste management practices.

Table of Contents

Introduction

The concept of a green and circular economy has gained significant prominence as societies worldwide grapple with the urgent need for sustainable development and responsible resource management. This paradigm shift represents a departure from the linear "take, make, dispose" model to one that prioritizes environmental stewardship, resource efficiency, and a regenerative approach.

The green economy focuses on fostering economic growth while minimizing environmental impact and promoting social equity. It places a premium on renewable energy, sustainable agriculture, and eco-friendly technologies to create a holistic and balanced framework for development. The circular economy, on the other hand, goes beyond minimizing harm; it aims to eliminate waste by designing products and systems that prioritize longevity, reuse, and recycling. These two complementary concepts converge in the pursuit of a regenerative and sustainable economic system. Central to the green and circular economy vision is the reevaluation of waste management practices. Traditional waste management systems, marked by linear processes of disposal and depletion, are becoming obsolete. Innovations in waste management play a pivotal role in reshaping this landscape, providing solutions that align with the principles of sustainability and circularity.

Waste management innovations are multifaceted and span the entire waste management hierarchy, from reduction at the source to efficient disposal. The adoption of smart sorting technologies, equipped with advanced sensors and digital tools, revolutionizes the sorting process by automating the identification and separation of various waste streams. Robotics further enhance efficiency, particularly in the handling and disassembly of bulky waste items, reducing reliance on manual labor and improving safety standards. Data analytics tools enable the optimization of pre-processing workflows, identifying patterns and predicting peak times for streamlined operations.

In the circular economy paradigm, waste is not merely discarded but viewed as a valuable resource. Recycling technologies, including advanced processes like chemical recycling, break down materials into their original components for more efficient reuse. The integration of circular design principles in product manufacturing ensures that materials are easily recoverable

and recyclable, closing the loop on material lifecycles. Furthermore, the circular economy encourages industrial symbiosis, where waste from one industry becomes a resource for another. By fostering collaboration and resource sharing among industries, this approach minimizes waste generation and maximizes resource efficiency across sectors.

The aim of this paper is to indicate the basic principles of the green and circular economy, with reference to innovative methods of waste management. Based on the goal of the thesis, two research questions were defined:

1. How can innovative technological solutions be effectively employed to advance the principles of the green and circular economy, particularly in the context of waste management?

2. What are the practical strategies and challenges associated with implementing circular economy principles, with a focus on reducing, reusing, and recycling waste, and how do these strategies contribute to sustainable practices and environmental preservation?

After the introduction, the paper is divided into four parts. In the first part, the key aspects of sustainable development are presented, from which the relevant principles of the green and circular economy, which are described in the second part, emerged. In the third part of the paper, the fundamental aspects of innovation are presented, where eco-innovations and innovations in the field of waste management are analyzed in a separate part. The fourth part of the paper presents case studies of companies operating in the Republic of Serbia and Italy. These are E-Recycling (from the Republic of Serbia) and Geocycle (from Italy). The Case Studies present innovative approaches to waste management in accordance with the principles of the circular economy

1. Sustainable development

1.1. The concept of sustainable development

Sustainable development is not a recent concept; it was initially coined in 1987 in the Brundtland Commission report. During that period, sustainable development primarily focused on ecological aspects, emphasizing the importance of respecting and protecting the environment and ensuring the sustainable use of resources. However, as time passed, various other issues emerged, predominantly in the social and economic realms. This broadened the scope of sustainable development, but, in essence, it can be defined as follows: "Sustainable development is the kind of development that meets present needs without compromising the ability of future generations to fulfill their own needs ".[1]

This definition emerged in response to the adverse effects of economic activities on natural resource consumption and environmental degradation. These impacts, over time, led to consequences not only in the ecosystem but also in the global environment and people's lives. Therefore, sustainable development advocates for development principles where resources are used responsibly, efforts are made to substitute non-renewable resources with renewable ones, and measures are taken to mitigate environmental pollution. Implementing sustainable development is crucial to ensuring that the needs of the current generation are met without jeopardizing the well-being of future generations. Consequently, two fundamental components of sustainable development can be identified:[2]

- Needs component - it is imperative to sustain ongoing economic activities to address the current needs of society.
- The concept of limitations - while pursuing the above, it is vital to utilize resources judiciously and responsibly. Beyond the immediate needs, consideration should be given to the requirements of future generations.

[1] Stojić Karanović, E.S, 2007, "Regionalna i prekogranična saradnja za održivi razvoj Srbije", Međunarodni problemi, 2(3), p. 343.
[2] Štrbac, N., Vuković, M., Voza, D., and Sokić, M, 2012, "Održivi razvoj i zaštita životne sredine", Reciklaža i održivi razvoj, 5, p. 19.

The escalating frequency of environmental issues has spurred the organization of numerous conferences on sustainable development. Under the auspices of the United Nations, these conferences took place in Stockholm in 1972, Rio de Janeiro in 1992, Johannesburg in 2002, and again in Rio in 2022.

The United Nations conference in Stockholm in 1972 marked a pivotal moment in environmental protection. Bringing together a diverse array of countries and their representatives, the objective was to enhance human rights and environmental well-being while emphasizing the interconnection between social and economic development to ensure environmental protection. The primary topics at this conference included water, food, secure housing, access to family planning, living conditions, and more.[3] Notably, it was during this conference that the international community, for the first time, discussed the importance and consequences of environmental pollution.[4]

The driving force behind organizing this conference was the recognition that global issues cannot be effectively addressed through individual policies or in isolation. What was deemed essential were not piecemeal measures but rather concerted efforts by all countries worldwide, fostering environmental protection through coordinated and integrated policies.[5]

The outcome of this gathering was the Stockholm Declaration, highlighting the significance and principles of balancing economic development with environmental protection. States were urged to integrate these two elements for sustainable progress. While acknowledging their sovereign right to use natural resources, nations were also obligated to restore and safeguard them for future generations. Consequently, principles of environmental development were to be seamlessly woven into economic development principles. Post this conference, many countries undertook substantial efforts to enhance their institutional frameworks and ensure environmental development and protection. This involved the implementation of various laws, rules, regulations, principles, and both formal and informal arrangements within the economy. Emphasis was also placed on minimizing the adverse environmental impact on neighboring

[3] Filipović, M, 2019, "Konceptualizacija održivog razvoja i ekološko obrazovanje", Vojno delo, 2, p. 55-68.
[4] Stojić Karanović, E.S, 2007, "Regionalna i prekogranična saradnja za održivi razvoj Srbije", Međunarodni problemi, 2(3), p. 340-375.
[5] Štrbac, N., Vuković, M., Voza, D., and Sokić, M, 2012, "Održivi razvoj i zaštita životne sredine", Reciklaža i održivi razvoj, 5, p. 18-29.

countries. This aspect is governed by a specific principle, essentially preventing the unbridled consumption and exploitation of a country's environment for resource extraction.

A few years after the Stockholm conference, the International Union for the Protection and Promotion of the Environment released the World Conservation Strategy as a precursor to sustainable development. Subsequently, in 1987, the World Commission for Environment and Development, known as the Brundtland Commission, was established, named after the Norwegian Prime Minister Harlem Brundtland. Operating independently under the United Nations, the commission produced a comprehensive document titled "Our Common Future," widely recognized as the Brundtland Report.[6] While certain aspects and problems of sustainable development had been raised earlier, it was the Brundtland Commission that addressed these issues more earnestly and in detail. The report underscored serious dangers for the entire planet if economic growth persisted without adhering to environmental protection principles. The overarching task became leaving natural resources of the same quantity and quality for future generations.[7]

The report of the Brundtland Commission underscores the significance of the interconnected relationship between humans, nature, and society. In contrast to the Stockholm report, the Brundtland Commission emphasized politically acceptable principles of sustainable development. Notably, the commission articulated a crucial position, stating, "Sustainable development is that development that meets current needs, without jeopardizing the ability of future generations to meet their needs".[8] Specifically, the Brundtland Commission highlights two fundamental concepts:

- The concept of needs: achieving and maintaining an acceptable standard for all people.
- The concept of limitations: utilizing the environmental capacity in accordance with the achieved level of technological and social development.

In the 1960s, when people initially became aware of environmental problems, these issues were perceived as discrete and mostly linked to industrial pollution. Consequently, corrective ad hoc

[6] Filipović, M, 2019, "Konceptualizacija održivog razvoja i ekološko obrazovanje", Vojno delo, 2, p. 55-68.
[7] Stojić Karanović, E.S, 2007, "Regionalna i prekogranična saradnja za održivi razvoj Srbije", Međunarodni problemi, 2(3), p. 340-375
[8] Štrbac, N., Vuković, M., Voza, D., and Sokić, M, 2012, "Održivi razvoj i zaštita životne sredine", Reciklaža i održivi razvoj, 5, p. 18-29.

policies, preferably involving technologies, were considered sufficient. However, by the 1980s, global concerns such as ocean contamination, ozone depletion, deforestation, and inadequate drinking water highlighted that environmental problems were systemic. It was recognized that the economic system, incompatible with ecological balance, needed transformation. The "Our Common Future" report of the World Commission on Environment and Development in 1987, also known as the Brundtland Report, not only marked the first institutional support for sustainable development but also gained approval from the United Nations.[9]

Following the United Nations conference in Stockholm in 1972, experts convened in Nairobi in 1982, warning about uncontrolled industrial development and its repercussions on natural resource utilization. The subsequent summit in Rio de Janeiro in 1992 underscored, for the first time, the correlation between economic development and the environment. This conference represented the apex of UN efforts in environmental protection and sustainable development. The United Nations Declaration, defining 27 principles of environmental protection for member states to integrate into national legislation, was adopted. Some of these principles expanded upon those outlined in the Stockholm Declaration, aiming to ensure environmental protection at both national and international levels. The conference, named the "Planet Earth Summit," included participation from 178 countries and over 100 heads of government. In addition to the principles, the conference adopted protocols and Agenda 21, aiming to enhance the quality of human life and improve the protection and management of natural resources.[10]

The Kyoto Protocol, emerging from a conference in Kyoto, Japan, in 1997, focused on reducing the emission of carbon dioxide and other harmful gases for sustainable development. It aimed to reduce emissions by 8% below the 1990 level by 2012. Notably, the Kyoto Protocol gained legal force in 1997 when ratified by 55 countries, despite being agreed upon in 1992. It came into effect in 2005 and has been signed by over 140 countries. The protocol aims to fulfill the goal of the 1994 Convention, stabilizing the concentration of greenhouse gases to prevent dangerous human-induced interference in the climate system.[11]

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[9] Bermejo, R., Arto, I., Hoyos, D., 2010, "Sustainable development in the Brundtland report and its distortion: implications for development economics and international cooperation", K. Unceta and A, Arrinda (eds.), Development Cooperation: Facing the Challenges of Global Change, Center for Basques Studies. University of Nevada, p. 14.

[10] Filipović, M, 2019, "Konceptualizacija održivog razvoja i ekološko obrazovanje", Vojno delo, 2, p. 55-68.

[11] United nations, 2003, "*Kyoto protocol to the united nations framework convention on climate change*", United nations, Geneva.

In 2002, another United Nations summit on environmental protection and sustainable development was held in Johannesburg. This summit, spanning two weeks, was more comprehensive and well-attended than the 1992 Rio de Janeiro conference. From August 26 to September 4, 2002, a significant gathering took place at the Sandton Convention Center in Johannesburg. This event brought together 82 heads of state and government, 30 vice presidents, 74 ministers, members of the royal family, and other high-ranking officials, alongside thousands of official representatives and civil society observers. The academic and scientific communities, local representatives, and the private sector also actively participated. In addition to the official summit attended by over 20,000 individuals, numerous parallel events and summits were organized worldwide to coincide with this conference. Collectively, these gatherings in Johannesburg highlighted crucial global challenges: widespread poverty, severe environmental issues, conflicting visions of development and globalization, and a lack of political will for sustainable development.[12]

The conference in Johannesburg acknowledged that significant efforts outlined in earlier conferences had not been realized. This was mainly attributed to major industrial polluters, such as the United States of America and Russia, not accepting the principles outlined in previous declarations. At that time, the Kyoto Protocol had not yet come into force, and its effects could not be discussed.[13]

One of the motives behind the 2002 Johannesburg conference was to rejuvenate global commitment to sustainable development and assess the progress made up to that point. The report evaluating the status of the implementation of Agenda 21 identified serious shortcomings, including a fragmented approach to sustainable development, insufficient progress in addressing unsustainable consumption and production patterns, inadequate attention to key policy issues of coherence in finance, trade, investment, technology, and sustainable development, as well as insufficient financial resources and a lack of a technology transfer mechanism between developed and less developed countries. The conference resulted in three key outcomes: a political declaration, the Johannesburg Implementation Plan, and the establishment of numerous partnership initiatives. The Johannesburg Declaration affirmed

[12] Antonio, G.M.L., Hoff, G., and DeRose, M.A., 2003, "The outcomes of Johannesburg: assessing the world summit on sustainable development", A Journal of International Affairs, p. 1-14.
[13] Popov, D, 2013, "Načela zaštite životne sredine u dokumentima Ujedinjenih nacija , Evropske unije i Zakona o zaštiti životne sredine Republike Srbije", Zbornik radova Pravnog fakulteta u Novom Sadu, 2, p. 131-146.

commitments made in Stockholm in 1972 and Rio in 1992, along with some Millennium Development Goals. Another significant outcome was the Johannesburg Plan of Implementation, which served as a program of action to guide government activities, covering key commitments and goals in areas such as sustainable consumption and production, water, sanitation, and energy. Additionally, the 2002 Johannesburg Conference formed voluntary transnational agreements known as partnerships. These agreements involved multiple stakeholders from governmental and non-governmental organizations, aiming to enable society to contribute to the implementation of sustainable development.[14]

Twenty years after the Rio conference in 1992, another conference was held in Rio de Janeiro, Brazil, gathering more than 60,000 delegates, activists, environmental organizations, representatives of large companies, and 170 world leaders. Commonly referred to as the Rio+20 conference, its goal was to unite world leaders in ensuring sustainable development, a decent standard of living, and the preservation of ecosystems and natural resources. As a result, a practical document containing sustainable development guidelines was produced. Detailed guidelines were also adopted for implementing green economy development policies, establishing intergovernmental relations within the General Assembly, and devising ways to finance the sustainable development strategy.[15]

1.2. Dimensions of sustainable development

Today, three key dimensions of sustainable development are recognized:[16]

1. Ecological Component: this dimension emphasizes the preservation of natural resources and biodiversity. It involves finding ways to replace non-renewable resources with renewable alternatives, thereby ensuring the long-term health and balance of the environment.

2. Social Dimension: sustainable development acknowledges the importance of meeting the needs of society. This dimension involves ensuring normal living conditions for all,

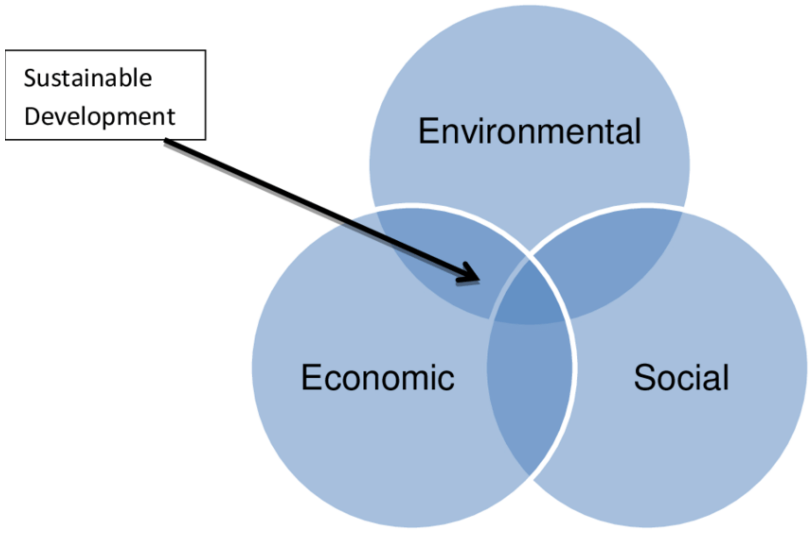
[14] European Sustainable Development Network, 2012, "The Rio+20 Conference 2012: Objectives, processes and outcomes", European Sustainable Development Network, Vienna, p. 5.
[15] Filipović, M, 2019, "Konceptualizacija održivog razvoja i ekološko obrazovanje", Vojno delo, 2, p. 55-68.
[16] Eadie, R., McKeown, C., and Anderson, K, 2011, The social element of sustainable civil engineering public procurement in Northern Ireland. *International Journal of Business and Social Science*, 2(12), p. 37

encompassing aspects such as social and cultural inclusion, poverty reduction, eradication of diseases, and other measures that enhance the overall well-being of communities.

3. Economic Dimension: the econmic dimension of sustainable development focuses on discovering innovative ways to sustain economic activities. The emphasis is on ensuring that economic processes are carried out in a manner that is environmentally responsible and socially inclusive, promoting long-term viability.

By integrating these three dimensions, sustainable development seeks a holistic and balanced approach that addresses environmental, social, and economic considerations to create a more resilient and equitable future.

Figure 1. The three dimensions of sustainability



Source: Eadie, R., McKeown, C., and Anderson, K, 2011, The social element of sustainable civil engineering public procurement in Northern Ireland. *International Journal of Business and Social Science*, 2(12), p. 37.

The principle of sustainability, particularly in the context of economic activities, is a fundamental concept in environmental conservation. Sustainability is viewed as a necessity to protect nature, maintain its functions, fulfill basic needs for future generations, and proactively engage in actions to preserve natural resources. In essence, sustainable development is characterized by meeting current needs without compromising the ability of future generations

to meet their own needs. Achieving sustainable development requires individuals, companies, and groups to align their actions in a way that ensures benefits from nature for the future.

Environmental protection should play a pivotal role in strategic decision-making, especially for companies with significant capacities that exert a substantial impact on nature through their operations. This involves efficient and minimized consumption of natural resources, the prevention of hazardous substance releases into nature, and the production of ecologically harmless products. To achieve this, companies need to adopt a sustainable development strategy based on the following principles:[17]

- Establishing a system for the protection and sustainable use of natural resources, including air, water, soil, mineral resources, forests, and more.
- Strengthening cooperation and achieving synergies between environmental protection and the development policies of other sectors.
- Investing in reducing environmental pollution and developing clean technologies.
- Reducing the high energy intensity of the economy and promoting more efficient use of fossil fuels.
- Utilizing renewable energy sources.
- Planning sustainable production and minimizing waste.
- Protecting and preserving biodiversity.

The ecological dimension of sustainable development emphasizes that economic growth and development must be considered in harmony with the characteristics and needs of the ecosystem. Furthermore, it underscores the importance of equality in societal positions and access to necessary resources. Preserving biodiversity, ensuring rational resource use, reducing environmental pollution, and caring for endangered species fall under the purview of the ecological dimension.

[17] Ilić, B., Jovanović, V., and Milovanović, D., 2011, "Menadžment i strategija održivog razvoja", Ecologica, 18, p. 32-40.

The economic dimension of sustainable development entails aligning economic activities, production capacities, and economic processes with the principles of nature and sustainable development. In this regard, environmental management becomes crucial, especially for large companies in processing and heavy industry. Environmental management, as a holistic approach, involves the protection, management, and restoration of the environment and ecosystems. It focuses on minimizing the negative environmental impacts of a company's products throughout their life cycle. An essential principle within ecological management is ecological efficiency, representing the delivery of products and services at competitive prices while gradually reducing negative environmental impacts and resource use to a level consistent with the Earth's estimated capacity. Environmental efficiency can be measured by factors such as the amount of wastewater, particles, air pollution, and similar indicators.

The concept closely tied to the economic dimension of sustainable development is clean production. It is a business strategy encompassing proactive strategies, policies, and activities aimed at establishing an environmentally friendly production process, thereby ensuring the safety and health of individuals. Achieving an ecologically clean production process involves several strategies:[18]

- Designing environmental management systems with competent experts assessing the impact of business operations on the environment and defining appropriate measures.
- Implementing the environmental protection management system ISO 14001.
- Assessing the impact of production and products on the environment.
- Measuring environmental performance indicators.
- Employing environmental accounting and similar practices.

The fundamental goal of clean production is to minimize or eliminate negative environmental impacts such as air, water, and soil pollution. This approach not only facilitates sustainable development but also provides a competitive advantage in an era where there is increasing emphasis on environmentally responsible practices. Clean production enhances

[18] Klaseen, R.D., and McLaughlin, C.P., 1996, "The impact of environmental management on firm performance", Management Science, 42(8), p. 1199-1214.

competitiveness by reducing resource consumption, yielding better results, improving operational performance, and fostering a positive public image.

The social dimension of sustainable development pertains to social relations, emphasizing respect for human rights, the achievement of social well-being, transparency, and particularly, social inclusion and participation in domains such as healthcare, social justice, education, human rights, safety, and housing. From a sustainable development perspective, the social dimension underscores the importance of development that meets the majority of society's needs, is fair, and includes characteristics such as:

- Fighting against poverty.
- Creating equal employment opportunities.
- Promoting social unification.
- Providing accessible healthcare and education.
- Crime prevention.
- Democratization of society.

Within the social pillar of sustainable development, critical aspects include the sustainable use of energy, availability of safe food and drinking water, disease prevention, adequate supply of necessary medicines, and provision of normal living conditions.[19] While the ecological component remains of paramount importance and complexity, encompassing various aspects of environmental protection and human health, the social dimension emphasizes the need for fair and inclusive development.

In summary, the economic dimension, represented by clean production, and the social dimension of sustainable development are intertwined, aiming to ensure economic growth while safeguarding environmental health and promoting social well-being. Achieving these dimensions contributes to overall sustainability and fosters a more resilient and equitable society.

[19] Environmental protection agency, 2020, "Sustainability primer", Environmental protection agency, Washington, p2.

1.3. Principles of sustainable development

To realize the numerous goals of sustainable development, certain principles need to be implemented. These principles guide the activities of both states and businesses, ensuring a balanced development approach. The formulation of a sustainable development strategy is crucial, encompassing the following activities:[20]

- Establishing a system for the protection and sustainable use of natural resources: this includes resources such as air, water, soil, mineral resources, and forests, among others.
- Development of a unique policy of economic development supporting ecological goals: aligning economic policies with ecological objectives ensures a harmonized approach that promotes both economic growth and environmental sustainability.
- Investing in reducing environmental pollution: allocating resources to initiatives that actively decrease environmental pollution is essential for achieving sustainability.
- Development of clean or "green" technologies: promoting the creation and adoption of environmentally friendly technologies is crucial for minimizing negative environmental impacts.
- Reducing the high energy intensity of the economy: implementing measures to lower the energy intensity of economic activities contributes to sustainable development by decreasing resource consumption and environmental impact.
- More efficient use of fossil fuels: optimizing the use of fossil fuels is essential in mitigating environmental degradation and supporting the transition to cleaner energy sources.
- Utilization of renewable energy sources: embracing renewable energy sources such as solar, wind, and hydropower is integral to reducing dependence on non-renewable resources and decreasing environmental harm.

[20] Ilić, B., Jovanović, V., and Milovanović, D., 2011, "Menadžment i strategija održivog razvoja", Ecologica, 18, p. 32-40.

- Waste reduction: implementing strategies to minimize waste generation and promoting recycling and responsible disposal methods are critical components of sustainable development.

- Protection and preservation of biodiversity: ensuring the conservation of biodiversity contributes to the resilience of ecosystems and the overall health of the environment.

To achieve sustainable development, the actions of both companies and individuals must be oriented towards deriving benefits from nature in the long term. This underscores the importance of incorporating environmental protection considerations into strategic decision-making processes, especially for developing economies like the Republic of Serbia. Neglecting natural resources during the development process can have detrimental effects, highlighting the need for a comprehensive and sustainable approach to economic and social progress.

To ensure sustainable development, it is crucial that the actions of companies and individuals are oriented towards obtaining benefits from nature in the long term. This is particularly important for developing economies, such as the Republic of Serbia, where natural resources can be neglected in the pursuit of intensifying the development process. A significant milestone in environmental protection efforts was the 1992 conference in Rio, where the UN Declaration on the Environment and Sustainable Development was adopted. Within this declaration, 27 principles of sustainable development were defined, intended to be incorporated into national environmental protection legislation. These principles build upon and elaborate the concepts presented at the Stockholm conference. Some key principles include:[21]

1. Sustainable Development: adapting the structure and dynamics of societal activities to the environment.

2. Integrality: ensuring economic development aligns with the integral system of environmental protection.

3. Preventiveness: Preventing environmental pollution at the point of origin.

[21] Popov, D, 2013, "Načela zaštite životne sredine u dokumentima Ujedinjenih nacija, Evropske unije i Zakona o zaštiti životne sredine Republike Srbije", Zbornik radova Pravnog fakulteta u Novom Sadu, 2, p. 132-133.

4. Impact Assessment Conducting assessments of the potential harmful impact on the environment before undertaking activities.

5. Quality: Executing environmental protection by defining a certain degree of protection quality.

6. Reuse and Recycling Considering materials that can be reused in economic activities, and recycling those that cannot.

7. User Pays: Entities using natural resources pay a fee for their use

8. Polluter Pays: Polluters bear the costs of endangering the environment.

9. Publicity of Data: Making data related to the environment publicly accessible.

10. Notification: Competent authorities providing objective and timely information about environmental protection and the state of the environment.

11. Education and Awareness Strengthening: Actively working on strengthening ecological awareness in society through schools, universities, and other institutions.

In the current context, the 2030 Agenda serves as a global action plan adopted by the United Nations in 2015. The main goal is to achieve sustainable development by 2030, encompassing 17 sustainable development goals. These goals cover various dimensions of sustainability, such as poverty elimination, gender equality, quality education, clean water and sanitation, sustainable forest management, and reduction of inequality, among others. The 2030 Agenda highlights the universality and interconnectedness of these goals, emphasizing the need for partnerships between governments, the private sector, civil society, and the international community. Achieving the 2030 Agenda requires global cooperation and coordination for sustainable and inclusive progress by 2030.

2. Green and circular economy

2.1. The concept of green economy

The green economy is the result of efforts to make the economy more environmentally responsible and advanced, aiming to create a balanced and positive impact on society and the environment. The term "Green Economy" originated in 1989 from the works of a group of British economists at the London Center for an Ecologically Sustainable Economy. However, as a concept, it has roots in the works of numerous researchers and scientists and has been a topic of discussion at United Nations conferences and efforts by non-governmental organizations to guide global development towards sustainability and responsible practices. The concept gained renewed attention during the 2008 economic crisis, seeking solutions to the challenges posed by the crisis and emphasizing sustainable development.

The United Nations Environment Program launched the Green Economy Initiative to establish a framework and garner political support for investments in the green economy. The initiative focuses on "greening" sectors of the economy that have a negative impact on the environment.

The UN conference on sustainable development, RIO+20, held in 2012, emphasized the further development of the green economy, with a greater focus on supporting developing countries in finding their own green economy models. Given the complexity of this development concept, each country should have a long-term green economy development plan with clearly defined priority areas. However, due to resource constraints (knowledge, technology, financial resources, and public support), poor and developing countries may not be able to initiate development in all areas simultaneously. The principles of the green economy include:[22]

1. Equal distribution of wealth.

2. Economic equality and justic.

3. Preservation of natural resources.

4. Careful approach to the environmen.

5. The right to development.

6. Collection of costs.

7. International cooperation.

8. International liability.

9. Information and participation.

10. Sustainable consumption and production.

11. Strategic cooperation and integrated planning.

12. Just transition.

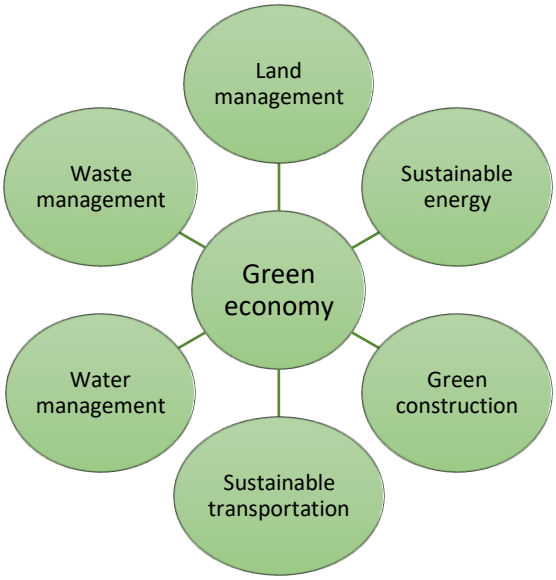
13. Redefining wealth.

14. Gender equality.

[22] Bina, O, 2013, "The green economy and sustainable development: an uneasy balance?" Environment and Planning Government and Policy, p. 1023-1047.

The conceptual aspects of the green economy encompass various elements, reflecting a holistic approach to sustainable development.

Figure 2. Green economy elements



Source: Vuković, S, 2019, "Zelena ekonomija i zeleno preduzetništvo", Smart kolektiv, Beograd, p. 15.

As can be seen, the green economy includes land management, use of renewable energy, green construction, water and waste management, but also sustainable transport, which requires, in addition to everything else, green marketing approaches.

2.2. Circular economy

In 1976, Stahel and Reday introduced concepts that can be regarded as the postulates and characteristics of the circular economy. They coined the term "loop economy" to describe business practices and strategies aimed at reducing waste, enhancing efficiency, and decreasing the industry's reliance on natural resources. Thus, the circular economy is inherently restorative and regenerative. It involves utilizing resources multiple times across various phases, making it a regenerative system that minimizes resource use, waste, gas emissions, and environmental

impact by narrowing material and energy loops.[23] The circular economy also entails maximizing resource efficiency, separating technical and biological cycles, and utilizing resources through several stages.[24]

This innovative approach focuses on reducing waste and using resources efficiently, challenging the traditional linear model of production (take, use, throw). Instead, it advocates for a system where products, materials, and resources are continually cycled. The primary objectives include minimizing waste, extending product life, and recycling materials to mitigate the negative impact on the environment. The circular economy encourages the use of renewable energy sources, innovations in degradable product design, and the promotion of sharing and reuse systems. Beyond environmental benefits, it drives economic advantages through cost reduction and job creation in recycling sectors. Implementing a circular economy necessitates collaboration between governments, businesses, and citizens to establish a sustainable and environmentally responsible economic model.

The circular economy embodies a holistic approach to better manage natural resources, covering all stages from resource utilization and production processes to consumption and waste management. This model places special emphasis on innovations and strategies that enhance efficiency, leading to a reduction in negative environmental impacts. By integrating circular principles, society and industry can realize significant benefits in terms of preserving natural resources, reducing harmful gas emissions, and creating more sustainable economic systems. Through improved product design, the promotion of sharing and recycling systems, the circular economy provides lasting solutions that positively impact ecology, economy, and society. Simultaneously, it encourages innovative practices and supports the transition to a more sustainable and responsible business model (Figure 3).[25]

Figure 3. Circular economy

[23] Geissdoerfer, M., Paulo, S., Bocken, N.M.P., and Jan Hultin, E, 2017, "The Circular Economy – A New sustainability paradigm?" Journal of Cleaner Production, 143, p. 764.
[24] Avramchikova, N., Rozhnov, I., Zelenskaya, T., Maslova, O., Avramchikov, V, 2021, "Circular economy and "green technologies"", E3S Web of Conferences, 291, p. 2.
[25] Vuković, S., Ćorić, G., Lisjak, D, 2019, "Zelena ekonomija i zeleno preduzetništvo", Smart, Beograd, p. 15.

Source: Vuković, S., Ćorić, G., Lisjak, D, 2019, "Zelena ekonomija i zeleno preduzetništvo", Smart, Beograd, p. 15.

The circular economy represents a revolutionary approach to the industrial model, which transforms traditional concepts of production and consumption through changes in design, efficient use of resources and attitude towards waste generation. The key feature of this model is the elimination of the concept of waste, given that materials are considered raw materials that can be indefinitely recycled and reused in the same or other production processes. The circular economy particularly emphasizes the advantage of renewable energy sources, efficient use of energy, support for innovative technologies, promotion of green public procurement, replacement of hazardous chemicals with less risky alternatives, and necessary changes in consumer habits. This approach not only eliminates the generation of unnecessary waste, but also lays the foundation for a more sustainable society, encouraging changes at the level of industry, public policy and consumer behavior.[26]

The implementation of the circular economy is based on three principles:[27]

[26] Kamberović, S, 2020, "Mapa puta za cirkularnu ekonomiju u Srbiji", Ministarstvo zaštite životne sredine, Beograd.
[27] Heshmati, A, 2015, "A review of the circular economy and its implementation", Forschungsinstitut zur Zukunft der Arbeit Institute for the Study of Labor, Bonn, p. 5.

1. Reduction of the use of materials, with the aim of reducing the use of resources and materials through increasing efficiency.

2. Reuse of materials through the use of waste and byproducts from previous stages of the production process.

3. Recycling of used materials.

Circular and sustainable economies share a common goal of addressing environmental challenges and promoting responsible resource management. Both concepts aim to minimize negative impacts on ecosystems and enhance long-term well-being. One key similarity lies in their emphasis on reducing waste and optimizing resource use. Both models encourage the adoption of eco-friendly practices, innovation, and responsible consumption to achieve a harmonious balance between economic growth and ecological preservation. However, there are nuanced differences between the two. While sustainability broadly encompasses ecological, social, and economic dimensions, circular economy primarily focuses on the efficient use and reuse of materials within the economic system. Sustainable development often involves a broader systemic shift in societal values, governance, and social equity, whereas the circular economy concentrates on redesigning production and consumption cycles. Despite these distinctions, both paradigms contribute to building a more resilient, environmentally conscious, and socially equitable future. Integrating aspects of both approaches may offer a comprehensive framework for achieving lasting positive change on a global scale.[28]

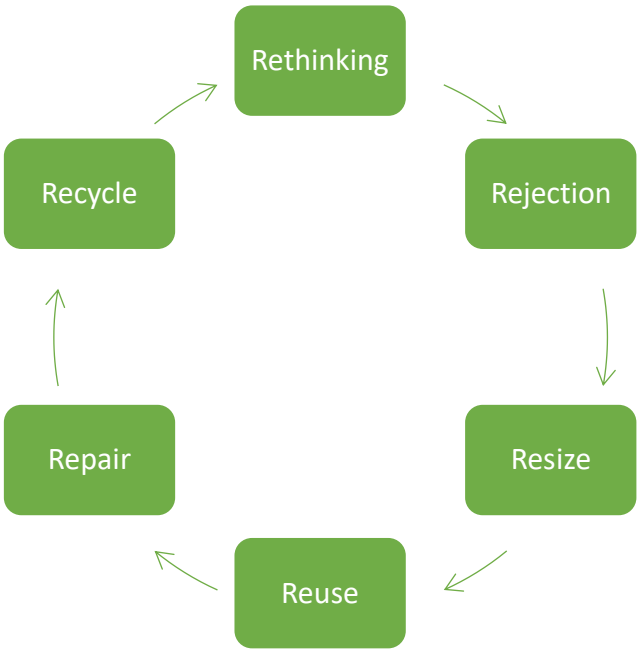
2.3. Circular economy - process

As previously highlighted, the linear economy operates on the principles of "Think, make, and throw away," which sharply contrasts with the circular economy. Given the scarcity and non-renewability of resources, discarding them prematurely is considered a luxury when there is still potential for further use. Moreover, numerous national laws, standards, and regulations are already aligned with international environmental protection standards, advocating for the minimized use of resources. Adhering to these standards often requires the deployment of

[28] Geissdoerfer, M., Paulo, S., Bocken, N.M.P., and Jan Hultin, E, 2017, “The Circular Economy – A New sustainability paradigm?” Journal of Cleaner Production, 143, p. 757-768.

modern technology to facilitate eco-innovations. Additionally, there are security considerations, as certain resources may hold strategic importance for national and economic security, necessitating their responsible use.[29] Figure 4 illustrates the 6R process of the circular economy.

Figure 4. 6R circular economy process



Source: Kamberović, S, 2020, "Mapa puta za cirkularnu ekonomiju u Srbiji", Ministarstvo zaštite životne sredine, Beograd, p. 11.

The 6R circular economy process is a comprehensive framework that outlines key principles for sustainable resource management. Each "R" represents a stage in the cycle, emphasizing a shift from the traditional linear model of take, make, and dispose to a circular system that prioritizes resource efficiency and minimizes environmental impact:[30]

1. Rethinking: this initial stage challenges conventional thinking and prompts a reevaluation of existing processes. It encourages businesses and individuals to question the necessity and sustainability of products and systems. Rethinking involves considering alternative materials,

[29] Heshmati, A, 2015, "A review of the circular economy and its implementation", Forschungsinstitut zur Zukunft der Arbeit Institute for the Study of Labor, Bonn, p. 8.
[30] Kamberović, S, 2020, "Mapa puta za cirkularnu ekonomiju u Srbiji", Ministarstvo zaštite životne sredine, Beograd, p. 11.

designs, and consumption patterns to align with circular principles. By fostering a mindset shift, this stage lays the groundwork for a more sustainable approach to resource use.

2. Rejection: this stage involves the conscious rejection of unsustainable practices and materials. It encourages the elimination of harmful substances, non-recyclable materials, and environmentally detrimental processes from the production cycle. By rejecting elements that contribute to environmental degradation, the 6R model promotes a cleaner and more responsible approach to resource utilization.

3. Resize: this stage stage emphasizes optimizing resource use by right-sizing products and processes. It involves minimizing excess and ensuring that products are appropriately scaled for their intended purpose. By avoiding overconsumption and unnecessary waste, resize contributes to resource efficiency and a more sustainable use of materials.

4. Reuse: promotes the extension of product lifecycles by encouraging multiple uses before the end of life. This stage emphasizes designing products for durability, reparability, and adaptability. Through encouraging reuse, the 6R model reduces the demand for new resources, mitigating the environmental impact associated with continuous production.

5. Repair: emphasizes the importance of maintaining and fixing products rather than discarding them when damaged or malfunctioning. This stage supports a shift towards a culture of repairability, encouraging manufacturers to design products with easily replaceable parts and providing consumers with access to repair services. Repair contributes to prolonging the lifespan of products and reducing the overall demand for new resources.

6. Recycle: the final stage and involves the recovery of materials from products at the end of their life cycle. This process ensures that materials are transformed into new products, closing the loop and reducing the need for virgin resources. Effective recycling systems play a crucial role in achieving a circular economy by minimizing waste and preserving valuable resources.

The 6R circular economy process provides a holistic approach to sustainable resource management, addressing various aspects of production, consumption, and waste. By implementing these principles, businesses and societies can contribute to a more circular, efficient, and environmentally friendly economic model.

3. Green and circular economy eco-innovations

3.1. Innovations – fundamental concepts

When the term "innovation" is used colloquially, the initial thought often revolves around something entirely new, valuable, and different. This perspective is justified as innovations typically involve introducing something novel. However, it is crucial to recognize that innovation doesn't necessarily have to be radically new or drastically different from existing concepts. Taking products as an example, innovation can encompass the modification and improvement of existing products, including their attributes, functions, design, packaging, and

more. This distinction between incremental and radical innovations is explained further below. Before delving into that, it's important to differentiate between the following three concepts:[31]

1. Invention: the development of a new idea.

2. Innovation: translating an idea into a practical solution.

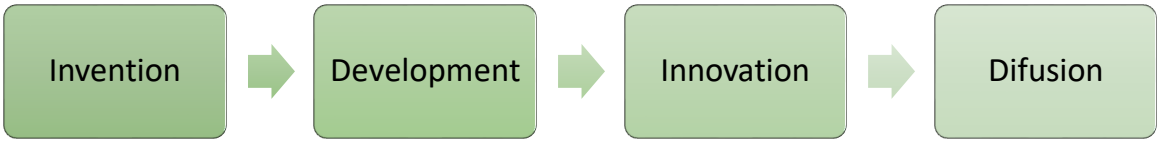
3. Diffusion: the distribution of a practical innovative solution in the market.

In a broader context, innovation involves a fresh approach to problem-solving across various domains, aiming to enhance quality, productivity, efficiency, reduce resource consumption, or increase end-user satisfaction with the created innovation. In a narrower economic view, innovation refers to a new solution generated within the economy or a company. This can be based on existing known solutions or derived from revolutionary new ideas. In essence, innovation depends on the application of a new or improved production procedure, process, product, or service. It introduces novelties in areas such as technological progress, process improvements, organizational and work structure innovations, and management strategies.[32]

To transform an invention into an innovation, substantial managerial efforts become imperative, necessitating meticulous planning and execution of decisions to ensure the success of the new idea. Critical managerial activities in this process include knowledge management, enabling change, fostering creativity, employee education, and similar initiatives.[33] The nature and intensity of these activities depend on the type and complexity of the innovation process. It underscores the importance of a prior comprehensive understanding of these concepts, as illustrated in Figure 5.

Figure 5. Transition of invention into innovation

[31] Novaković, V., Peulić, V., and Matijević, G., 2020, "Inovacija kao pokretač ekonomskog razvoja", Časopis za ekonomiju i tržišne komunikacije, 10(1), p. 233.
[32] Vujisić, D., and Spasić, V, 2012, "Inovativnost - ključna determinanta unapređenja konkurentnosti", Zbornik radova Pravnog fakulteta, 39, p. 74.
[33] Vujisić, D., and Spasić, V, 2012, "Inovativnost - ključna determinanta unapređenja konkurentnosti", Zbornik radova Pravnog fakulteta, 39, p. 76.



Source: Novaković, V., Peulić, V., and Matijević, G., 2020, "Inovacija kao pokretač ekonomskog razvoja", Časopis za ekonomiju i tržišne komunikacije, 10(1), p. 233.

The innovation process initiates with the invention phase, where the primary focus is on generating new ideas or discovering creative solutions. Invention involves creating something entirely new, whether it is a product, process, service, or idea, or enhancing existing ones. Following the invention phase, the idea or concept progresses into the development phase. Here, the emphasis shifts to refining and elaborating the initial idea, transforming it into a tangible prototype or a more detailed plan. Development activities encompass feasibility studies, creating prototypes, and evaluating the practicality and viability of the innovation. This phase is critical for identifying potential challenges, fine-tuning the concept, and ensuring alignment with market requirements and organizational capabilities. The innovation phase marks the point at which the concept is introduced to the market or implemented within the organization. This phase involves the practical application of the idea, its integration into existing systems, processes, or products. Diffusion, the final phase, pertains to the spread and adoption of an innovation through the market or within an organization. This phase includes communication, marketing, and distribution strategies aimed at promoting the innovation and encouraging its adoption.

The development and success of innovations depend on various factors. Initially, it's essential to highlight that the innovative capacity of an organization hinges on four key factors: organizational culture, resources, knowledge, and teamwork among employees:[34]

[34] Selaković,, M., Ljepava, N. and Đeletović, M, 2018, "Upravljanje inovacijskim promenama u savremenom okruženju", Vojno Delo, p. 449.

- Organizational culture determines how employees approach challenges, take risks, and accept changes. A culture that values experimentation, creativity, and open communication tends to encourage innovation.

- The availability of resources, including financial, technological, and human resources, significantly affects an organization's capacity to innovate. Adequate resources provide the necessary support for experimentation, research, and development.

- The knowledge base within an organization, including the skills and expertise of its workforce, plays a key role in driving innovation. An expert workforce can generate, analyze, and apply information to solve complex problems and identify opportunities.

- Effective collaboration and teamwork are fundamental to innovation. Cross-functional teams bring together the diverse skills and experiences of employees, fostering a dynamic environment for generating creative solutions.

In conclusion, innovation in organizations is a multidimensional process influenced by the collective impact of organizational culture, resources, knowledge, and teamwork. Organizations that proactively foster a culture of innovation, invest in resources, encourage continuous learning, and promote effective teamwork are better positioned to adapt to change, seize opportunities, and remain competitive in a dynamic business environment. Numerous entities inside and outside the organization participate in the development of innovative ideas and their translation into tangible solutions. In other words, sources of innovation can be:[35]

- top managers,

- mid-level managers, often based on insight into existing workflow problems,

- employees, who are directly involved in work processes and know their essence best,

- business processes and technology used during work,

- research and development activities (in most cases),

[35] Novaković, V., Peulić, V., and Matijević, G., 2020, "Inovacija kao pokretač ekonomskog razvoja", Časopis za ekonomiju i tržišne komunikacije, 10(1), p. 236.

- subjects from the external market (customers, business partners, suppliers, state authorities, etc.),
- competitors.

Considering the above, as a result, innovations in products, services, processes, ways of working, organization of business and so on can occur. In addition to the above, the so-called levers of the innovation process should be highlighted:[36]

- technological progress,
- customer demands on the market for new products and services,
- actions of competitors in the field of development of new products, services and business ideas,
- improvement of the business model,
- stakeholder requirements for value creation.

Technological advances drive innovation by introducing new tools, methods and opportunities to improve business processes, enabling organizations to improve products, services and processes to remain competitive. Customer demands shape innovation by influencing the creation of products and services aligned with customer preferences, increasing satisfaction and driving market success. Organizations respond to competitors' initiatives with the goal of outperforming them and doing better, which encourages the development of new products, services and business strategies for market leadership. Business model improvement drives innovation by prompting organizations to re-evaluate and improve their fundamental approaches to operations, revenue generation and stakeholder value delivery.

Given that in the context of innovation one can talk about completely new and unique solutions, as well as their modification and improvement, it is necessary to first distinguish between radical and incremental innovations.

[36] Zakić, N., Stamatović, M., and Cvetanović, S, 2009, "Tipologija inovacija u preduzećima", Ekonomske Teme, 52(2), p. 75.

Radical innovations are transformative and introduce entirely new concepts, often changing or creating entirely new markets, redefining industry standards, and significantly altering the competitive landscape. They involve high levels of uncertainty and risk but can provide sustainable competitive advantages and spur growth by creating new markets. On the other hand, incremental innovation involves gradual improvements or refinements to existing products, services, or processes. While they may not bring revolutionary changes, incremental innovations are crucial for maintaining competitiveness, improving efficiency, and meeting customer needs. These innovations focus on small, predictable changes, building on existing knowledge, technologies, or business models.[37]

The Oslo Manual by the Organization for Economic Co-operation and Development (OECD) identifies four types of innovation:[38]

1. Product Innovation: involves creating or improving products and services. This innovation type focuses on enhancing features, functionality, or quality, leading to the development of new offerings or improvements to existing products.

2. Process Innovation: aims at optimizing operational methods, systems, or techniques in the production or delivery of goods and services. the goal is to improve efficiency, reduce costs, and enhance overall business processes.

3. Organizational innovation: refers to the restructuring or creation of new structures, jobs, and ways of performing tasks within the organization. This innovation type often involves changes in leadership, management, and communication strategies.

4. Marketing Innovation: includes changes in the way products or services are presented, promoted, and communicated to consumers. It encompasses strategies for branding, advertising, distribution channels, and customer engagement, seeking to create a unique market position and improve brand recognition.

These types of innovation cover various aspects of business, from product development and operational efficiency to organizational structure and marketing strategies. Successful

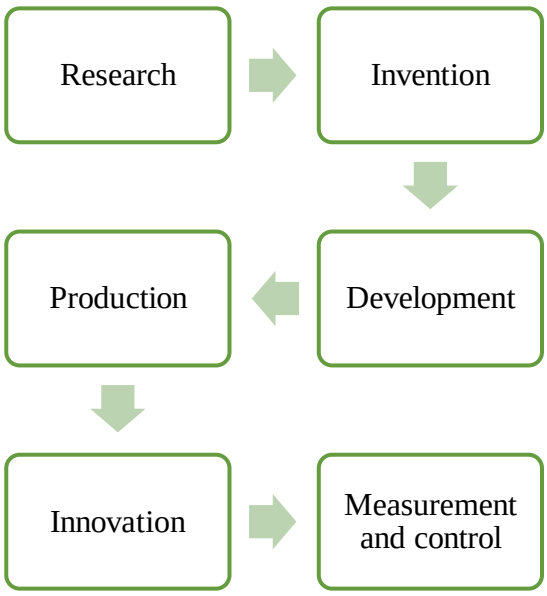
[37] Vujisić, D., and Spasić, V, 2012, "Inovativnost - ključna determinanta unapređenja konkurentnosti", Zbornik radova Pravnog fakulteta, 39, p. 78-79.
[38] OECD, 2009, "Innovation in firms: a microeconomic perspective", Paris: OECD, p. 11-12.

organizations often engage in a combination of these innovation types to adapt to changing environments and stay competitive.

3.2. Innovation management

In order to create unique and valuable solutions and translate them into practice, with the aim of exploiting market opportunities, it is very important to implement adequate principles of managing innovation processes. As with the definition of innovation, it should be emphasized that there is no single approach to innovation management. One of them is shown through the activity in Figure 6.

Figure 6. Innovation management



Source: Dajić, M, 2017, "Uloga i značaj inovacija u razvoju privrede Srbije", Ekonomski Signali, 12(1), p. 57.

Innovation management begins with research and development, where opportunities are identified and potential innovations are conceptualized. This phase focuses on understanding market needs, technology trends, and the company's internal capabilities. As stated earlier, invention implies the creation of a new idea based on previous research and development activities. After invention, the development phase transforms concepts into products or services. This includes creating prototypes, solving technical challenges, and optimizing the

innovation for application. This is followed by the production phase and the creation of the innovation. As it is distributed in the market, it follows the measurement of the effects of the innovation, which includes the evaluation of the rate of user adoption, the increase in market share, and the financial result.[39]

3.3. Eco-innovation as a specific concept in innovation theory

Environmental innovation is a concept closely tied to sustainable development and environmental efficiency. Ecological efficiency, the relationship between created value and environmental impact, is crucial for achieving sustainable development. In this context, ecological innovations emerge as specific solutions, products, services, and processes designed to minimize environmental impact while fostering the growth of created value.[40]

The concept of ecological innovation, within innovation theory, gained prominence in the mid-1990s. In essence, eco-innovations involve the application of eco-efficient technology. Eco-efficient technology directly or indirectly enhances environmental quality, encompassing technologies that reduce pollution, promote environmentally friendly products and production processes, facilitate resource management efficiency, and develop technological systems with less harm to the environment.[41]

Similar to traditional innovations, there is no universally accepted definition of eco-innovations. One approach characterizes environmental innovations as those achieving a positive impact on the environment while providing benefits to the innovator. An ecological innovation is one capable of delivering a dual profit—both a positive environmental impact and economic benefits. From the perspective of industrial dynamics, environmental innovations are those capable of attracting "green rents" in the market. Another perspective defines environmental innovation as the creation, assimilation, or exploitation of a product, production process, service, management or business method that is novel to the organization and results in the reduction of environmental risks, pollution, and negative impacts on resource use throughout

[39] Vujisić, D., and Spasić, V, 2012, "Inovativnost - ključna determinanta unapređenja konkurentnosti", Zbornik radova Pravnog fakulteta, 39, стр. 84.
[40] Marinescu, C., Ciocoiu, C.N., and Cicea, C, 2015, "Drivers of eco-innovation within waste electrical and electronic equipment field, Theoretical and Empirical Researches in Urban Management, 10(4), p. 7
[41] Kemp, R., and Pearson, P, "Final report MEI project about measuring ecoinnovation, Paris: OECD.

its life cycle, compared to relevant alternatives. In essence, environmental innovations can be seen as forms of innovation facilitating significant progress toward the goal of sustainable development. This progress involves reducing environmental impact or achieving a more efficient and responsible use of natural resources, particularly emphasizing decreased energy consumption. Thus, environmental innovations encompass a broad range of products, services, and processes that not only refrain from negatively impacting the environment but also yield economic benefits.[42]

Hence, environmental innovations are those pertaining to products, services, and processes that avoid creating negative impacts on the environment while generating economic benefits. They signify any innovation that actively pursues substantial and visible progress towards sustainable development by either minimizing environmental impact or ensuring more efficient and responsible utilization of natural resources, with a particular emphasis on reduced energy consumption.[43]

Also referred to as sustainable innovation, environmental innovation encompasses the development of inventive products, ideas, processes, and behaviors geared towards reducing harmful environmental impacts or promoting sustainable development. It goes beyond green technology or environmentally friendly product development and can involve modifying existing business conditions to achieve sustainability. This may include the introduction of recycling systems, finding new ways to reduce harmful gas emissions, waste minimization, and more.[44]

Environmental innovation strategies aim to decouple economic growth from environmental degradation and strive for greater resource efficiency. The objective is to minimize the use of natural resources throughout the entire business process while simultaneously reducing the environmental impact of business activities. Environmental innovation opportunities are diverse, spanning low-carbon solutions, green products and waste-free business models, to

[42] Pereira, A., and Vence, X, 2012, "Key business factors for eco-innovation: an overview of recent firm-level empirical studies", Cuadernos de Gestión, 12, p. 75.
[43] Fernando, Y., Xin, W.W., Gani, A.B.D, 2016, "Five drivers of eco-innovation: insights from parsimonious model using a content analysis approach". International Journal of Disease Control and Containment for Sustainability, 1(1), p. 16.
[44] Naz, F., Magda, R, 2019, "Sustainable development through eco-innovation: drivers and barriers", Sustainability, Environment, Safety, p. 145-146.

smart infrastructure and improved ecosystem management. Environmental innovations encompass not only product and service innovations but also innovations in business processes and management. Adopting new management approaches that minimize negative environmental impacts is a crucial aspect. As instruments for sustainable development, ecological innovations involve measures and actions by relevant market actors—companies, politicians, associations, private households, non-governmental organizations—who develop, apply, or introduce new ideas, services, products, and processes with the aim of lessening the burden on the environment.[45]

Examples of ecological innovations include special filter-equipped chimneys to prevent harmful gas emissions, carbon dioxide sequestration and storage in fossil fuel power plants, improved efficiency with reduced water use, building insulation, water-efficient washing machines, energy-efficient household appliances, closed production processes in industry, and machines using renewable energy sources.[46]

Various types of eco-innovations can be distinguished, including additions to innovations (technology and services for pollution and resource management), integrated innovations (cleaner technological processes and products), innovations of an eco-efficient technological system (new technological paths), innovations of an eco-efficient organizational system (new organizational structures), ecologically efficient innovations of general purpose (e.g., renewable energy and ICT), and measures to prevent pollution in existing processes, cleaning technology, internal process recycling, and pollution and process measurement technology.[47]

In contemporary business environments, ecological innovations emerge as a key factor for success and competitiveness. Organizations can enhance the value of their products and services through environmental innovation, contributing not only to economic development but also to economically sustainable development.

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[45] Szylagyi. A., Mocan, M., Verniquet, A., Churican, A., Rochat, D. 2018, "Eco- innovation, a business appro ach towards sustainable processes, products and services", SIM 2017 / 14th International Symposium in Management, p. 477.

[46] Urbaniec, M, 2015, "Towards sustainable development through eco-innovations: drivers and barriers in Poland", Economics & Sociology, 8(4), p. 181.

[47] Carrillo-Hermosillam J, 2009, "What is eco - innovation?" In: Eco - innovation, eds: Carrillo-Hermosilla, J., Río González, P.,& Könnölä, T., London: Palgrave-McMillan, p. 15.

3.3. Eco-innovations characteristics

The concept of environmental innovation is intricately tied to sustainable development, tracing its roots back to the 1970s when the first conference of this nature took place in Stockholm, marking the formulation of initial guidelines on improving environmental protection. Since then, various approaches have been defined to cultivate ecological innovations, involving the generation of new ideas and the conceptualization of products and services designed to minimize negative impacts on the environment. Environmental innovations offer several advantages, a key characteristic being the improvement of environmental performance. Organizations, in pursuing environmental innovation, not only accrue economic benefits but also contribute to the well-being of society by preventing degradation of soil, air, water, and natural resources. Assessing whether eco-innovation has occurred can be based on the enhanced environmental and economic performance, providing a foundation for comparison with competitors and guiding strategic decisions for sustained positive performance and competitiveness. Hence, environmental innovations not only enhance environmental sustainability but also generate positive economic effects.[48]

Countries with advanced economic development, such as Germany, France, the United States of America, Japan, New Zealand, and others, prioritize sustainable development in their economic growth models. This underscores the global recognition of the importance of environmental innovation in fostering both economic prosperity and ecological well-being.[49]

The basic characteristics of the economic growth and development of such countries are as follows:[50]

- increased investments in ecological innovations, i.e. the development of green technology, green processes, research and development, science and education,
- eco-innovation activities, such as the implementation of the ISO 14001 series of standards,

[48] Pensera, M, 2012, "The origins and purpose of eco-innovation", Global Environment: A Journal of Transdisciplinary History, p. 130-135.
[49] Naz, F., Magda, R, 2019, "Sustainable development through eco-innovation: drivers and barriers", Sustainability, Environment, Safety, p. 146.
[50]Janovac, T., Brzaković, M., Radanov, P., Brzaković, P, 1994, "Ekološke inovacije u službi održivog razvoja", *Ecologica*, p. 41-47.

- responsible waste management,
- development of patents in the field of environmental protection,
- responsible use of energy,
- productivity of the use of raw materials etc.

Today, these characteristics of ecological innovations are more and more characteristic of less developed economies, which have actively participated in the development of sustainable development policies. The following positive effects of ecological innovations can also be singled out:[51]

- reduced carbon dioxide emissions,
- reduced water and soil pollution,
- noise reduction,
- reduced use of materials per unit of production,
- improvement of food quality,
- improvement of people's health.

The Eco-innovation Observatory, an institution operating within the European Union, delineates the following categories of ecological innovations:[52]

- Ecological material flow innovations: These are systemic innovations that focus on material value chains in products and processes, aiming to reduce the amount of material used while enhancing product quality.

- Environmental product innovation: Involves the development of new products or services with minimal overall impact on the environment.

- Process environmental innovations: Encompass improvements in production and delivery methods to minimize environmental impact.

[51] Fernando, Y., Xin, W.W., Gani, A.B.D, 2016, "Five drivers of eco-innovation: insights from parsimonious model using a content analysis approach". International Journal of Disease Control and Containment for Sustainability, 1(1), p. 16-17.
[52] Dahan, S.M., Yusof, S.M, 2020, "The typologies of eco-innovation", Service and Operation Management: Series, 2, p. 85.

- Organizational environmental innovation: Pertains to the socio-economic dimension of process innovation, including pollution prevention schemes, environmental management and audit systems, and supply chain management.

- Marketing-ecological innovations: Involve changes in product design, packaging, distribution, promotion, or pricing.

- Socio-ecological innovation: Encompasses market-based dimensions of behavioral and lifestyle changes, as well as the demand for green goods and services.

- Infrastructural/systemic environmental innovation: Focuses on integrated system solutions for housing, urban parks, transport, and other major infrastructure forms, aiming to understand and improve the environmental impact of products, processes, or organizational changes. This involves a series of related innovations that enhance or create entirely new systems with reduced overall environmental impact.

Regardless of their specific form, ecological innovations consistently deliver a positive impact on the environment. They facilitate the development of high-quality products and services, contributing not only to the economic benefits of the organizations involved but also positively affecting society as a whole. Typically, organizations engaged in eco-innovation processes prioritize social responsibility over mere profit. The value created by these organizations extends beyond individual economic gains, fostering a positive impact on the entire economic system. This, in turn, enhances the competitiveness of the national economy on the global stage.

3.4. Waste management innovations

3.4.1. Technological factors of waste management

Apart from the regulatory framework, the advancement of environmental innovations heavily relies on technology and technological progress. Green technology, in particular, plays a crucial role in quality certification related to environmental protection, patent creation, and waste management, making it a cornerstone in the field. The degree to which various natural resources

are utilized, as well as the efficiency and effectiveness in environmental innovation, are influenced by the type and age of the technology in use.[53]

Adopting the Resource-Based View of the firm, success for organizations and national economies is linked to possessing resources that are rare, valuable, and challenging to imitate. In the context of ecological innovations, modern technology, particularly green technology, is highlighted as a relevant resource. Green technology facilitates environmentally friendly solutions, supporting clean processes in production, recycling, and waste management. Organizations aspiring to excel in environmental innovation need to dedicate considerable attention to researching and developing technology that will drive advancements in later stages. Acquiring relevant technology for environmental innovation can also be accomplished through partnerships, leasing, mergers, and acquisitions with other organizations in the field.[54]

Technology, alongside knowledge, constitutes an integral component of the knowledge economy. Therefore, the process of ecological innovation becomes a crucial factor that can provide a competitive advantage, especially when leveraging modern and digital solutions. Various factors driving different technologies have been identified as significant drivers of environmental innovation. The technological capacities of organizations, encompassing resources necessary for developing, adapting, generating, and managing technical changes, represent a key driving force for environmental innovations. Organizations investing continuously in research and development and maintaining a highly qualified workforce are more likely to exhibit environmental innovation characteristics. Given the dynamic nature of eco-innovations, involving substantial investments in research and development, complementary investments in machinery, equipment, and software become imperative for successful eco-innovation activities.[55]

Green technology, highlighted earlier in the context of ecological innovations, represents a form of technological progress encompassing various methodologies and material improvements. It

[53] Sobczak, E., Gluszczuk, D., Raszkowski, A, 2020, "Eco-innovation and innovation level of the economy as a basis for the typology of the EU countries", International Journal of Environmental Research and Public Health, 19, p. 4.
[54] Kiefer, C.P., Gonzalez, P.D.R., Carillo-Harmosilla, J, 2018, "Drivers and barriers of eco- innovation types for sustainable transitions: A quantitative perspective", Business Strategy and the Environment, 28, p. 159.
[55] Kemp, R., 2011, "Ten themes for eco-innovation policies in Europe", Sapiens, p. 12.

ranges from energy generation techniques to products that have a minimal or no negative impact on the environment. Important aspects of such technology include:[56]

- new or improved use of natural resources, in such a way as to eliminate the use of non-renewable resources,
- identification of alternatives for how organizations can reduce waste and pollution through improved use of environmental resources or through the discovery of new uses for such resources,
- removal of harmful substances from the environment, which can be dangerous for human health,
- recycling,
- reuse of materials.

As an integral part of environmental innovation, green technologies are gaining increased attention, driven by growing environmental concerns. Innovations in green technologies offer a dual advantage: they contribute to the reduction of environmental degradation while simultaneously promoting the technological modernization of the economy. Therefore, green technologies play a pivotal role in achieving a balance between environmental protection and economic development, a crucial aspect for fostering sustainable development. These technologies encompass biotechnology and nanotechnology, information and communication technologies, as well as environmental technologies. Their application enhances resource efficiency and minimizes harmful impacts on the environment, providing benefits not only to individual entities but also to the broader economy and society. Green technologies find applications in the production of goods and services, logistics, transportation, marketing, wastewater treatment, climate change mitigation, and waste management.[57] The benefits extend beyond individual actors to contribute positively to the entire economy and society. Leveraging modern technological solutions for ecological innovation necessitates specific human capital, emphasizing the importance of educating employees in these domains.

[56] Fernando, Y., Xin, W.W., Gani, A.B.D. (2016). Five drivers of eco-innovation: insights from parsimonious model using a content analysis approach. *International Journal of Disease Control and Containment for Sustainability*, 1(1), p. 17.
[57] Urbaniec, M, 2015, "Towards sustainable development through eco-innovations: drivers and barriers in Poland", Economics & Sociology, 8(4), 179, p. 2-8

3.4.2. Waste management eco-innovations

The term waste management is not recent, and simply put, it represents the treatment and management of different forms of waste. However, that management process can have a sustainable or unsustainable dimension.[58] Waste management involves a number of key stages aimed at efficient and responsible waste handling. These phases include the prevention and reduction of waste, reuse and recycling of materials, collection, transport, processing, and disposal of waste, all of which are closely supervised. The main goal of this system is to minimize negative impacts on the environment and promote a sustainable approach to waste management. As part of waste management, different procedures are applied to achieve efficient waste treatment. These procedures include disposal, incineration, recycling, and biological recovery. Disposal refers to the controlled placement of waste at specific landfill sites. Incineration involves controlled thermal treatment of waste to reduce volume and potential environmental risks. Recycling encourages the reuse of materials to reduce the need for new resources. Bioremediation includes processes such as composting, where biodegradable waste is used to restore soil. Through the systematic implementation of these phases and procedures, waste management contributes to environmental preservation and sustainable development, creating a balance between human activities and the protection of natural resources.[59]

An adequate approach to waste management ensures a positive contribution to environmental protection. The first priority is to put waste under control, but this is not enough, it is necessary to move from a linear to a circular economy. In the earlier period, waste management focused only on collection, disposal, incineration or landfill processes. However, these approaches have their drawbacks, which, combined with the increasing importance of environmental protection and technological progress, created the need for innovation in waste management.[60] The

[58] Picart, I.C.E. and., Rauf, R, 2021, "Sustainable and innovative waste management loops", Master thessis, Linköping University, Department of Management and Engineering, Linköping University, p. 77.
[59] Vuković, S., Ćorić, G., Lisjak, D, 2019, "Zelena ekonomija i zeleno preduzetništvo", Smart, Beograd, p. 25.
[60] Petkova-Kozovska, S.M, 2017, "Innovative solutions in waste processing", International Scientific Journal "Innovations in Discrete Productions, 5(2), p. 83.

traditional approach to waste management that had a sustainable character included the following waste management methods:[61]

- Disposal: involves a series of methods for reusing and recycling waste, with the aim of converting it into energy

- Landfilling: a waste management method wherein solid waste is disposed of in designated land areas. The waste is compacted and covered with soil daily to minimize environmental impact. While common, landfills can pose environmental concerns such as methane emissions and soil contamination, prompting a preference for more sustainable alternatives.

- Incineration: a method of converting waste into substances such as ash or gas by burning waste at extremely high temperatures. Energy is often generated from waste through this process.

Modern waste management technology can include:[62]

- Underground Waste Collection Systems: waste bins are located underground, typically at a depth of 2-3 meters, and usually involve a plastic container for collecting different types of waste

- Web-Based GIS (Geographic Information System): involves utilizing online platforms to analyze, visualize, and manage spatial data related to waste. This technology aids in optimizing collection routes, monitoring landfill usage, and enhancing overall efficiency in waste management operations through real-time data access and geospatial analysis.

- Web-Based GSM (Global System for Mobile Communications): refers to mobile communication technology accessed through web platforms. It allows users to manage and control GSM devices remotely using web interfaces. This technology facilitates monitoring, tracking, and communication with mobile devices over the internet,

[61] Al Rawahi, M. Y., Naidu, V. R., Al Harthi, M. S. A., Al Riyami, N. H. S., Mohammed, Q. A., Babiker, S., and & Venugopal, D, 2020, "Innovations in smart cities for waste management: a review", International E-Journal of Advances in Social Sciences, 6(17), p. 725.
[62] Parveen, N., Singh, V., Azam, R, 2020, "Innovations in Recycling for Sustainable Management of Solid wastes", IGI Global, Hershey, p. 180-183.

offering convenience and accessibility for various applications, including fleet management and IoT devices.

- Compact Garbage Collection Trucks: specialized vehicles designed for efficient waste management. These trucks are smaller in size, making them suitable for navigating through narrow urban streets. Equipped with compacting mechanisms, they compress collected waste, optimizing load capacity. Compact garbage trucks play a crucial role in enhancing the maneuverability and productivity of waste collection services in densely populated areas, contributing to more effective and sustainable urban waste management practices..

One of the innovative approaches today involves using the Internet of Things (IoT) in waste management. The sensor technologies in question are connected to each other via a wireless network, with the aim of continuous data sharing, which is later used for analysis and decision-making. Their integration with waste bins leads to the development of Smart waste bins, which first of all send data on the degree of occupancy and the need for emptying. IoT sensors are deployed in waste bins, collection vehicles, and processing facilities to create an interconnected system that improves efficiency and sustainability. In waste bins, sensors monitor fill levels, enabling optimized collection routes and reducing unnecessary pickups. Smart waste bins equipped with IoT technology can also detect and sort recyclables automatically. Collection vehicles are fitted with GPS and sensor technology, allowing for real-time tracking, route optimization, and proactive maintenance scheduling. Additionally, IoT facilitates remote monitoring of landfill conditions, including leachate levels and gas emissions, ensuring timely intervention and environmental compliance. The integration of IoT in waste management promotes resource efficiency, reduces operational costs, and minimizes the environmental impact of waste disposal. By providing real-time data and insights, IoT enables waste management authorities to make informed decisions, enhance overall service quality, and move towards more sustainable practices. This interconnected system not only streamlines waste collection processes but also contributes to a smarter and more environmentally conscious approach to handling waste in urban areas.[63]

[63] Al Rawahi, M. Y., Naidu, V. R., Al Harthi, M. S. A., Al Riyami, N. H. S., Mohammed, Q. A., Babiker, S., and & Venugopal, D, 2020, "Innovations in smart cities for waste management: a review", International E-Journal of Advances in Social Sciences, 6(17), p. 726.

Among the innovative approaches to waste management, one option includes the application of robotics. Currently, robotics is already used in waste management through automated collection and sorting of waste. However, further digitization and the development of smart robotics are expected in the coming period, focusing on automatic recognition and sorting of specific types of waste. Building on the Internet of Things (IoT), a significant volume of data will be collected during waste management. Storing this data in conventional hardware space within a company might not be feasible, necessitating a cloud solution. Cloud computing emerges as an innovative solution in waste management, greatly streamlining administrative processes. Moreover, utilizing these solutions is often more cost-effective than independently expanding memory space. Many cloud solutions also enable big data analytics, where the analysis process can yield valuable insights.. Algoritmi mašinskog učenja na osnovu tako velikog obima podataka omogućavaju razvoj veštačke inteligencije (AI). It offers innovative solutions for optimizing various aspects of waste management, making the entire process more efficient and sustainable. In waste sorting facilities, AI-powered systems can enhance the accuracy of waste sorting by identifying and categorizing materials through computer vision and machine learning algorithms. These systems can rapidly and precisely sort recyclables from non-recyclables, improving recycling rates and reducing contamination. AI can also be applied to route optimization for waste collection vehicles. By analyzing historical data, traffic patterns, and real-time information, AI algorithms can optimize collection routes, minimizing fuel consumption and reducing emissions. This leads to cost savings and a more environmentally friendly waste collection process. Furthermore, predictive maintenance powered by AI can enhance the efficiency of waste management equipment. Sensors and data analytics can predict potential issues, enabling proactive maintenance measures to prevent breakdowns and downtime. In landfill management, AI can be employed to monitor and analyze environmental conditions, such as leachate levels and gas emissions. This data-driven approach helps in early detection of potential issues, allowing for timely interventions and minimizing negative environmental impacts. Overall, AI in waste management streamlines operations, improves recycling outcomes, reduces environmental impact, and enhances the overall sustainability of waste management practices. Integrating AI technologies not only makes waste management

more efficient but also contributes to a smarter and more adaptive approach to handling the challenges of growing waste volumes in urban areas.[64]

[64] Berg, H., Sebestyen, J., Bendix, P.,Blevennec, K.L., and Vrancken, K, 2020, "Digital waste management", European Environment Agency, Copenhagen, p. 13-17.

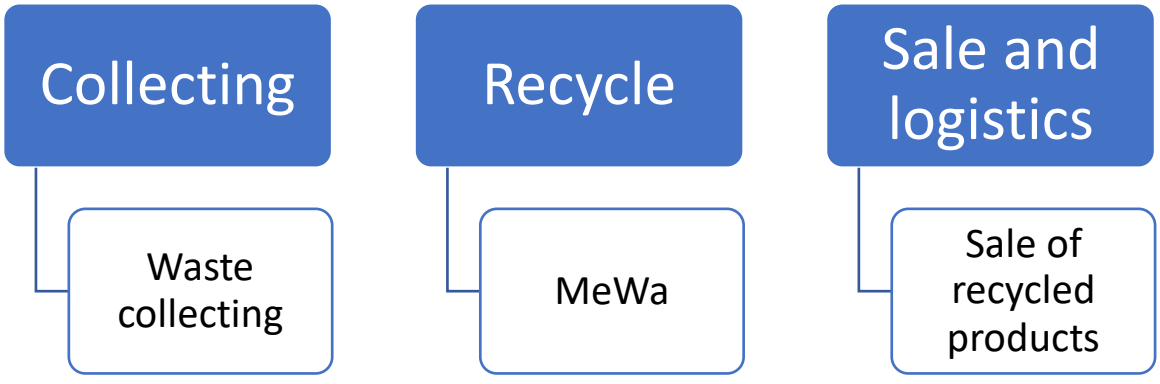
4. Waste management and eco-innovations solutions: case studies

4.1. Case study: example from Republic of Serbia

The Republic of Serbia is still working towards achieving a high level of development in terms of sustainability and innovative eco-solutions, particularly in waste management. However, at the microeconomic level, there are entities demonstrating impressive results, and one such standout company is E-Reciklaža (English: E-Recycle).

Founded in 2010, E-Reciklaža is a leading player in the recycling of electrical and electronic waste in the Balkans. Their primary activities encompass the collection, transport, storage, and treatment of electrical and electronic waste. Drawing from extensive global experience in waste management, particularly in the disposal, treatment, and reuse of electrical and electronic waste, E-Recycling successfully recycles an impressive 15,000 tons of waste from all categories each year. Their dedication to recycling aligns with sustainability goals and contributes to reducing the ecological footprint, with the consistently high recycling volume highlighting their pivotal role in addressing the regional issue of e-waste. Figure 7 illustrates the sectoral structure of the company in the waste management field..

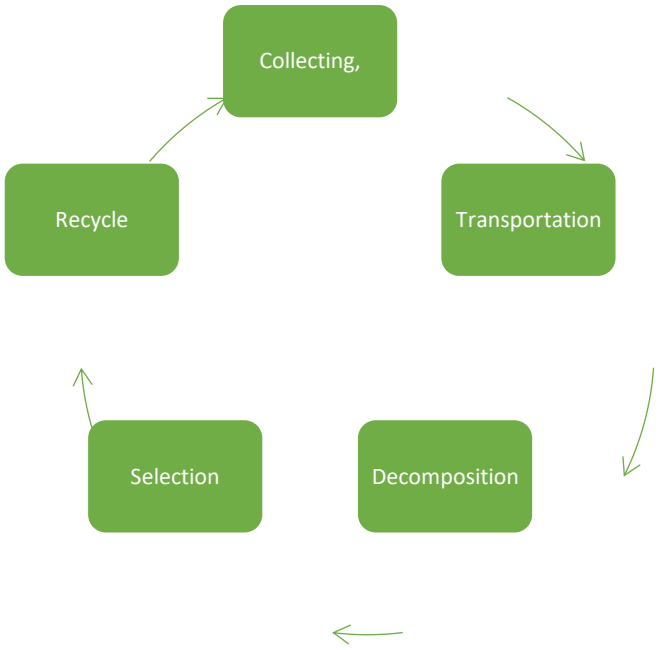
Figure 7. E-Reciklaža waste management department structure



Source: E-Reciklaža, https://www.ereciklaza.com/, retrieved 25.02.2024.

The waste management process at E-Reciklaža commences with the collection of waste directly from the premises of individuals or companies. Once the waste is transported to the company, it undergoes processing on a significant recycling line named MeWa. This specialized line dismantles the waste into distinct parts based on the type of material. Materials identified as recyclable and suitable for reuse in the production process, aligning with the principles of the circular economy, are then transported and sold to customers within the country. Figure 8 illustrates the waste management process.

Figure 8. Waste management process in the company E-Reciklaža



Source: E-Reciklaža, https://www.ereciklaza.com/, retrieved 25.02.2024

The company first collects waste at the addresses of individuals and companies and transports it to its warehouses in the four largest cities in Serbia: Belgrade, Novi Sad, Kragujevac and Niš. After that, the waste is decomposed. In landfills, organic waste undergoes natural decomposition over an extended period. Anaerobic digestion facilities utilize innovative technologies to accelerate organic waste decomposition, capturing and utilizing methane for energy production. Implementation of composting technologies to convert organic waste into valuable compost. As the company is particularly oriented towards electronic waste, it is specially selected in the company, using robotics with sensors for automatic detection and separation of such waste. The sensors send data to the central computer about the amount and type of waste at all times, so that accurate insight into the statistics is provided at all times and

thus creates a basis for making future decisions. This is followed by the recycling of waste by the previously described methods in the company. Sustainable approach to waste management included social dimension too. Namely, if the waste to be recycled contains relevant and confidential, as well as personal data (such as telephones or hard disks), in accordance with the certified approach, experts first decompose the equipment into parts. Then the parts that contain the information are destroyed with a shredder into very small pieces, so that the data can never be accessed.[65]

Annually, the company processes and disposes of 100,000,000 units of waste, predominantly electronic waste. This substantial outcome represents a commendable achievement, particularly within a context where waste management infrastructure is underdeveloped. To uphold a high standard of quality and sustainability, the waste management process adheres to recognized quality standards, including ISO14001 and ISO45001. Additionally, specific preventive measures are implemented to safeguard air, soil, and watercourses. Engaging in collaboration with the Global Fund for the Environment, the Ministry of Environmental Protection, and UNDP, the company actively participates in the "End of Waste for Pure Foam" project. Aligned with the principles of the circular economy, this project unfolds in two phases. In the initial phase, freon is extracted from cooling devices, with the ultimate aim of removing 10 tons of this gas. The subsequent phase involves the separation of the pure foam remaining in the product, transforming it into a new product—an absorbent. This absorbent material will serve the purpose of collecting gasoline and oil in case of spills into the environment.

The company has patented the following innovative solutions in waste management:

- Chain carrier for the universal cross-circulator waste shredder;
- System for monitoring the mechanical load of the universal cross-circulator waste shredder.

The *Chain carrier for the universal cross-circulator waste shredder* refers to a component or mechanism designed for the waste management process, specifically in conjunction with a universal cross-circulator waste shredder. In waste management, shredders are used to break down and reduce the size of waste materials, making them more manageable for subsequent

[65] E-Reciklaža, https://www.ereciklaza.com/, retrieved 25.02.2024.

processing or disposal. The "chain carrier" suggests a system involving chains, which could be part of the shredder's structure or operation. Chains may be employed to convey waste materials through the shredding process, ensuring a continuous and efficient operation of the waste shredder. On the other hand, the *System for monitoring the mechanical load of the universal cross-circulator waste shredder* indicates the presence of a monitoring system integrated into the shredder. This system likely involves sensors or technology that assesses and measures the mechanical load on the shredder during its operation. Monitoring the mechanical load is crucial for optimizing performance, preventing overloading, and ensuring the equipment operates within safe and efficient parameters.

4.2. Case study: example from Italy

As an illustrative instance of a company in Italy that aligns waste management with the tenets of eco-innovation, green practices, and the circular economy, Geocycle stands out. Operating within the Holcim Group, Geocycle has been effectively overseeing waste management for three decades and is at the forefront of incorporating circular economy principles into its operations. The company, headquartered in Tradate, specializes in the management of diverse waste categories, including wood, derivative, pharmaceutical, and automotive industry waste. To be more specific, Geocycle handles the following types of waste:[66]

- non-recyclabe plastic,
- mineral waste (contaminated soil, construction waste, iron, calcium, aluminum),
- biomass,
- liquid waste.

Through co-processing emissions in production, it becomes feasible to markedly diminish and close material cycles throughout the entire value chain. Industrial and municipal waste is recycled and employed as heat energy through alternative fuels. Consequently, fossil fuels like coal can be substituted, leading to a substantial reduction in CO2 emissions. The cement industry also efficiently repurposes mineral waste, such as contaminated soil from construction

[66] Geocycle, https://www.geocycle.com/, retrieved 24.02.2024.

sites, acting as a substitute for natural raw materials like limestone and marl. This strategy plays a pivotal role in fostering a more sustainable and environmentally friendly footprint for the cement industry (Figure 9).

Figure 9. Circular economy approach to waste management process

Source: Geocycle, https://www.geocycle.com/, retrieved 24.02.2024

At Geocycle, the waste management process is carried out in the following way:[67]

- Collection and transportation: transport and other means are used for loading, unloading and transportation of waste.
- Laboratory testing: experts in the laboratory test the waste to determine whether it can be reused in production cycles.
- Pre-processing: application of modern technologies and work methods in order to select waste and prepare it for further treatment.
- Co-processing: final waste is the recycling or destruction of waste.

[67] Geocycle, https://www.geocycle.com/, retrieved 24.02.2024.

Innovative solutions are instrumental in transforming the waste pre-processing stage, introducing efficiency and sustainability into the waste management system. Advanced technologies, such as smart sorting systems with sensors and robotic technologies, enable automated and precise sorting of various waste types, reducing reliance on manual labor. Data analytics tools offer the ability to optimize pre-processing workflows by analyzing historical data, identifying patterns, and predicting peak times for streamlined operations. The use of RFID tags facilitates tracking individual waste items throughout the pre-processing stage, ensuring seamless monitoring and traceability. Integration of robotics into the handling and disassembly of bulky waste items enhances safety and precision in separating valuable components. Through these innovations, organizations can elevate the efficiency of sorting processes, increase recycling rates, reduce contamination, and contribute to a more sustainable and effective waste management approach.

Conclusions

The imperative shift towards a green and circular economy, underscored by innovations in waste management, signifies a profound commitment to sustainable practices and the well-being of our planet. The synergy between the green and circular economy models propels a transformative journey from a linear to a regenerative approach to resource consumption and waste generation.

Waste management innovations emerge as dynamic catalysts within this transformative landscape, reshaping traditional paradigms and fostering a more responsible and efficient handling of resources. From advanced sorting technologies and robotics to data analytics, these innovations span the entire waste management hierarchy, contributing to a more streamlined, transparent, and sustainable system. The convergence of green and circular economy principles in waste management is instrumental in fostering a paradigm where waste is not a burden but a valuable resource. By treating waste as a potential asset and integrating circular design principles into product lifecycles, industries can significantly reduce their environmental footprint and contribute to a more circular and regenerative system.

Innovations in waste management technologies are steering the industry toward a more efficient and sustainable future. Modern waste management technology encompasses diverse solutions, including underground waste collection systems, web-based GIS, web-based GSM, and compact garbage collection trucks. These technologies optimize waste collection routes, enhance landfill monitoring, and improve overall operational efficiency.

One notable innovation is the integration of Internet of Things (IoT) in waste management. IoT sensors interconnected through wireless networks enable continuous data sharing for analysis and decision-making. Smart waste bins equipped with IoT technology relay information about fill levels, optimizing collection routes and reducing unnecessary pickups. This interconnected system, spanning waste bins, collection vehicles, and processing facilities, promotes resource efficiency, lowers operational costs, and minimizes environmental impacts. Robotic applications in waste management represent another innovative approach. While robotics are already employed in automated waste collection and sorting, future developments anticipate smart robotics capable of automatic recognition and sorting of specific waste types. The integration of robotics with IoT generates substantial data during waste management, necessitating cloud computing solutions for storage and analysis. Cloud computing not only

facilitates data management but also streamlines administrative processes, offering cost-effective solutions and enabling big data analytics. Machine learning algorithms driven by AI leverage vast datasets for waste sorting accuracy and route optimization, contributing to increased recycling rates and reduced environmental impact. Predictive maintenance powered by AI ensures proactive equipment upkeep, minimizing downtime and enhancing overall operational efficiency. AI's application extends to landfill management, where it monitors environmental conditions for early issue detection and intervention.

Based on theoretical framework and analysis, answers on research questions can be provided. When it comes about first research question, the circular economy principles, encompassing concepts such as recycling, reusing, and reducing waste, form the foundation for sustainable waste management practices. Eco-innovation, involving the development and implementation of new solutions, plays a crucial role in advancing technological methods for waste reduction. Through the adoption of green and circular economy principles, organizations can minimize environmental impact, promote resource efficiency, and contribute to overall sustainable development. The study highlights the integral role of eco-innovation in driving technological advancements that facilitate efficient waste management, creating a more circular and environmentally conscious approach to handling resources.

When if comes about second research question, companies like E-Reciklaža and Geocycle exemplify the practical application of circular economy principles and innovative technologies in waste management. E-Reciklaža specializes in electrical and electronic waste recycling, contributing significantly to the circular economy by collecting, treating, and reusing e-waste. Geocycle, operating within the Holcim Group, showcases a comprehensive waste management approach based on circular economy principles, managing various types of waste, including wood, pharmaceutical, and automotive industry waste. Both companies prioritize sustainable practices, aligning with circular economy principles and demonstrating the positive environmental impact achievable through the integration of innovative solutions into waste management processes.

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