# Circular Economy – Shaping a Sustainable Future

Biogas
SRBIJA

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# PREFACE

At a time when we are facing unprecedented environmental challenges, from climate change to the depletion of natural resources, the need to radically change the way we produce, use and manage resources has never been greater. In this context, the circular economy stands out as a key concept that offers sustainable solutions to many of today's challenges, promoting a model in which resources are used more efficiently and waste is reduced to a minimum or eliminated altogether.

The brochure "Circular Economy – Shaping a Sustainable Future" was created out of the desire to bring this important subject closer to a wide range of readers – **from academia, through entrepreneurs and managers, to decision-makers and the general public.**

Written with the aim of informing, educating and inspiring, this brochure is a comprehensive guide through the basics of the circular economy, its principles, benefits, as well as practical examples and strategies for implementing this model in the biogas sector, as one of the key examples of the circular economy model.

Based on decades of experience in working in the biogas sector, this brochure conveys all the experience of the Serbian Biogas Association, in order to explain what the circular economy is and how it can be applied in practice to the example of biogas. Through the presentation of information, practices, and personal insights, the brochure illustrates how the transition to a circular economy is not only vital for the preservation of our planet, but can also provide significant economic benefits, encouraging innovation, generating new market opportunities and creating new jobs.

The aim of the brochure is to encourage thinking and action as regards transitioning our society towards sustainability, as well as to provide the practical tools and knowledge needed to achieve this goal.

Thank you for recognising the importance of this subject and choosing to become part of a vital discussion on environmental responsibility on the route to a sustainable future by reading this brochure, as it is only through joint action and commitment that we can hope for a better future for all of us.

## INTRODUCTION TO THE SUBJECT AND IMPORTANCE OF THE CIRCULAR ECONOMY IN THE MODERN WORLD

In a rapidly changing world, we are faced with a series of challenges that shape our reality. One of the greatest, and perhaps the most important, challenges for modern man is protection of the environment.

A growing awareness of the serious consequences that irresponsible management of natural resources has for our economy, social justice and quality of life creates an urgent need for change in the course of action. These challenges require well thought out, urgent responses from all of us. In this context, sustainable development emerges not only as a moral imperative, but also as a key global priority leading to the integration of environmental, economic and social goals into a single framework for the future.

Nowadays, we face major environmental challenges, such as climate change, loss of biodiversity, pollution, overexploitation of natural resources, and other environmental problems that require our undivided attention. The consequences of these challenges are limitless and affect every aspect of our lives. In this regard, the traditional linear model for the economy, based on the "take, use, dispose" principle, can no longer be considered to be sustainable. We need a new way of thinking about the economy, but also about our relationship with nature.

The circular economy represents this new way of thinking, offering a model that is both restorative and regenerative in nature. Based on the principles of waste reduction, reuse of materials and conservation of natural resources, the circular economy represents a practical realisation of sustainable development in the economic system. The goal is to enable an economy that serves both people and the planet, promoting environmental sustainability, economic efficiency and social inclusion.

As a renewable energy source obtained from the processing of organic waste, biogas is one of the best examples of the application of the principles of a circular economy and will thus be discussed in more detail in the brochure. The use of biogas not only reduces dependence on fossil fuels and greenhouse gas emissions, but also offers a solution for the management of organic waste, thus contributing to the conservation of natural resources and reduction in waste. ■

# 01 THE CIRCULAR ECONOMY AND ITS HISTORICAL DEVELOPMENT

## DEFINITION OF THE CIRCULAR ECONOMY AND HOW IT DIFFERS FROM THE TRADITIONAL, LINEAR ECONOMY

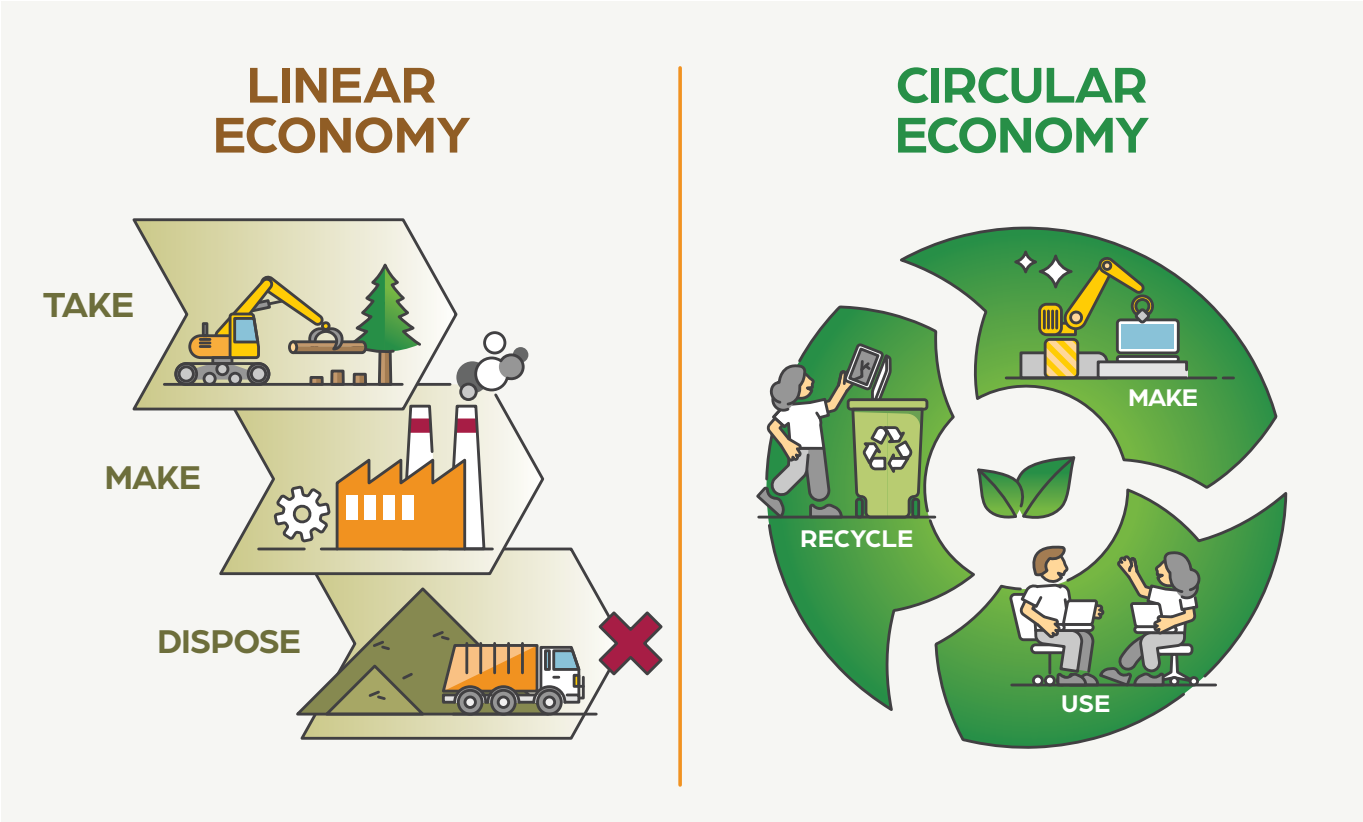
The traditional linear economic model, characterised by a sequential flow of resources, from extraction through production and consumption to final disposal, has long been the foundation for industrial growth. This model has brought significant economic gains, accelerating production and meeting market needs, thus contributing to the expansion of industrial production, stimulating employment and generating profits.

However, this approach has inherent weaknesses that call its long-term sustainability into question. Therefore, the fundamental problem in this model lies in its unsustainability, since it continuously relies on the exploitation of natural resources, often ignoring the limitations to them. This way of managing resources results in their rapid depletion and significant ecological degradation.

In addition, a large quantity of resources is lost during production processes, leading to unnecessary consumption of energy and materials and the creation of large volumes of waste.

The linear model also highlights disparities in the distribution of resources and wealth, with the concentration of resources in the hands of a small number of companies or countries potentially leading to economic inequality and social problems. In addition, inadequate waste management can result in soil, water and air pollution, endangering human health and ecosystems.

In light of these challenges, it is imperative to transition to a circular economy. The circular model advocates the optimal use of resources, encouraging their reuse, overhaul, recycling and regeneration, thus creating a zero-waste economy. The goal is to minimise environmental damage through more efficient management



of resources and materials, thereby supporting sustainable development and achieving greater environmental and economic efficiency. The circular economy not only reduces negative environmental impacts but also opens up new opportunities for innovation, competitiveness and economic development, while contributing to socio-economic inclusion and sustainable prosperity.

For the circular economy to become a fundamental part of the route to sustainable development, synergies between governments, industry, the scientific community, civil society and citizens are required. It is only through our combined efforts that we can ensure that the circular model becomes the foundation of economic activity, thus contributing not only to environmental protection but also to the creation of new business opportunities, economic growth and social well-being.

Public policymakers can contribute to the development and implementation of policies that encourage innovation, provide financial incentives for sustainable practices, and establish regulatory frameworks for effective waste management and protection of natural resources.

As an innovative and comprehensive approach, the circular economy paves the way for a future in which economic development is not achieved at the expense of nature, but rather based on its conservation, guaranteeing prosperity and quality of life for present and future generations.

# 01 THE CIRCULAR ECONOMY AND ITS HISTORICAL DEVELOPMENT

## EARLY DEVELOPMENT OF THE CIRCULAR ECONOMY AND ITS FOUNDATIONS IN SUSTAINABLE DEVELOPMENT

Even ancient civilisations instinctively applied the principles that today constitute the foundations of the circular economy. By intuitively understanding the value of the resources at their disposal, these traditional communities aimed to maximise the use of materials and minimise waste.

In pre-industrial societies, the concept of recycling, repairing and reusing was daily practice, driven by need and the scarcity of resources. These communities were aware of the limited natural resources, which led them to develop effective strategies for their management. For example, in agrarian societies, plant remains were used as fertiliser to enrich the soil, while damaged tools were carefully repaired rather than being simply discarded.

However, with the onset of the Industrial Revolution in the 18th and 19th centuries, the paradigm of production and consumption was radically transformed. The Industrial Revolution introduced mass production, which exponentially increased the availability of material goods. This increase in production was accompanied by the adoption of a linear "take, make, dispose" model, which did not consider the long-term consequences for the environment and resources. As a result, there has been significant environmental degradation, depletion of natural resources, and increase in waste.

Faced with these consequences, it became necessary to review the way resources were used in production. By looking critically at the linear model and its shortcomings, traditional recycling, repair, and reuse practices have come to be considered as the basis for a new, more sustainable economic model. In this regard, the concept of a circular economy has come to be perceived as a vital response to the environmental challenges of the post-industrial age, emphasising the need to close the loop in resources through their reuse, recycling and recovery.

The early development of the circular economy shows how the basic principles of this concept have not changed over time, but rather have adapted to modern needs and technologies. Returning to the principles of a circular economy, with the use of modern technologies and innovations, is a key step towards a sustainable future, in which resources are used efficiently and their value is preserved to the greatest extent possible.

## THE EVOLUTIONARY PATH OF THE CIRCULAR ECONOMY

The evolutionary path of the circular economy is a fascinating journey through time, from the basic instinctive practices of recycling and reuse in traditional societies to the developed conceptual frameworks used today to mitigate global environmental challenges.

At the heart of the evolution of the circular economy is the work of Kenneth Boulding, who, in 1966, presented a visionary view of the planet Earth, emphasising the closed nature of the economic system and interaction between economics and the environment. His work "The Economics of the Coming Spaceship Earth" is a revolutionary appeal for a paradigm change in the perception of the relationship of humanity to nature and the economy, initiating the first theoretical statements about the unsustainability of the linear economic model and the need for a holistic, integrative approach that considers the environmental limitations of the planet.

The "Earth spacecraft" model emphasises the finite nature of our planet's resources and the need to manage them carefully.

In the 21st century, the circular economy has made significant progress thanks to global initiatives and policies aimed at promoting sustainable development. The European Union has been a pioneer in adopting ambitious targets for the transition to a circular economy, putting regulations and incentives in place that support waste reduction, increased resource efficiency, and innovation in production and consumption. These initiatives have inspired other countries and entities to recognise and implement circular principles in their own economies, thus affirming the circular economy as a globally accepted model for sustainable economic development.

Today, the circular economy is not only an environmental imperative, but also an economic opportunity that offers solutions to some of the most pressing global challenges, promoting economic resilience, innovation and social inclusion. Its continuous evolution and application in different sectors and at different levels of society is crucial in achieving a sustainable future.

# 01 THE CIRCULAR ECONOMY AND ITS HISTORICAL DEVELOPMENT

## THE FOUR KEY COMPONENTS OF THE CIRCULAR ECONOMY

The circular economy model is developed around four key components that together constitute its foundation: resource and energy recycling, a multiple approach, sustainable development and innovation.

- **Recirculation of resources and energy** is the foundation of the circular economy, which is based on the idea that resources should not be used in a one-off linear process, but rather continuously reintegrated into the economic cycle.
- **Multi-level access** reflects the understanding that the circular economy is not limited to individual actions or industries, but rather encompasses a wide range of actors, from local communities to global economic systems.
- **Sustainable development** is at the core of the circular economy, seeking to harmonise economic, environmental and social goals.
- **Innovation** is the key to the success of the circular economy, enabling a transition from traditional production processes to more sustainable, efficient models.

Together, these four key components of the circular economy provide the foundation for building a more sustainable and resilient economic system.

## KEY PRINCIPLES OF THE CIRCULAR ECONOMY

The circular economy is a model for economic development that creates a closed loop in which resources are used more efficiently, with the aim of minimising waste and maximising the value of products and materials. This model is based on several key principles that enable the transition from a traditional, linear model to a more sustainable and environmentally more responsible approach.

The principles of the circular economy are the fundamental ideas that define the concept and guide how it is implemented. They encompass a broad understanding of how society should manage resources, products and waste to achieve sustainability. The key principles of a circular economy include waste minimisation, resource reuse, recycling and recovery.

- **The principle of waste minimisation** is aimed at reducing the amounts of waste generated during production and consumption. This is achieved through innovative product design that allows for easy repair, upgrade, and recycling, as well as optimising the production process to reduce raw material and energy consumption. The goal is to completely eliminate waste or turn it into a resource.

- **Reuse of resources** refers to the multiple use of existing materials and products before they become waste. This includes practices such as repairing and overhauling products, as well as developing products that can be easily disassembled and reassembled, thus allowing for their long-term use and reducing the need for new resources.

- **Recycling** is the process of converting waste materials into new products or raw materials. This principle is crucial in the circular economy as it allows materials that would otherwise end up as waste to be reintroduced into the production cycle. This reduces the need to extract new resources, saves on energy and resources, and reduces the impact on the environment.

- **Restoring resources** refers to processes that restore ecosystems and natural resources to their previous state or improve their sustainability. These include practices such as land restoration, afforestation, and protection of water resources. The principle of restoration is important for maintaining the health of the planet and ensures that natural systems can continue to provide essential resources and services.

# 01 THE CIRCULAR ECONOMY AND ITS HISTORICAL DEVELOPMENT

## THE IMPORTANCE OF SUSTAINABLE DEVELOPMENT IN UNDERSTANDING AND IMPLEMENTING THE CIRCULAR ECONOMY

To understand the concept and importance of the circular economy, we need to understand what sustainable development means. The basic elements of sustainable development include environmental responsibility, economic efficiency and social justice, with the aim of achieving harmony between man and nature, as well as between different social and economic groups.

Sustainable development is based on the idea that our current linear economy is unsustainable in the long run, as such a model leads to the depletion of natural resources, environmental pollution and major social inequalities. The circular economy offers an alternative that seeks to close the loop, whereby resources can be reused and value is created over a longer period of time.

Sustainable development provides us with a framework to think about an economy which is not only profit-oriented but also preserves our planet and ensures a just society for all inhabitants.

The circular economy is thus not merely an economic model, but an ethical and practical response to the challenges of sustainable development. It is the path to a future in which economic growth does not take place "at the expense of" our planet and future generations.

## HOW DOES SERBIA STAND ON THE ROUTE TO A CIRCULAR ECONOMY?

The implementation of a circular economy in Serbia is still in its infancy. There are some examples of successful projects and initiatives, such as recycling programmes, the use of renewable energy sources in some businesses, as well as the development of green start-ups. However, more systematic promotion of circular business models and additional support from the state in the form of financial incentives and educational programmes are needed.

One of the main challenges in promoting the circular economy in Serbia is the absence of wider awareness of the benefits of this approach, both among citizens and within the business community. It is also necessary to strengthen the capacity and infrastructure for recycling, composting and reusing materials.

To accelerate the transition to a circular economy, Serbia needs clear action plans, greater investment in green technologies and sustainable industries, as well as continuous alignment with European legislation and practice. Incorporating the circular economy into education curricula and raising public awareness of the importance of resource conservation and environmental protection are also key steps towards achieving sustainable development.

The circular economy can potentially transform Serbia's economic system, offering solutions to the many environmental challenges the country faces. From reducing the amount of waste that ends up in landfill to more efficient use of resources, to creating new green jobs, the benefits of switching to a circular economy model are numerous. Realising this potential requires joint work, commitment and innovation from all those involved.

In adopting a circular economy, Serbia has the opportunity to become a regional leader in sustainable development and environmental responsibility. By investing in education, establishing an appropriate legal framework and strengthening cooperation between all segments of society, Serbia can create a stable and sustainable economic system that will serve as an example of good practice and inspiration for other countries. ■

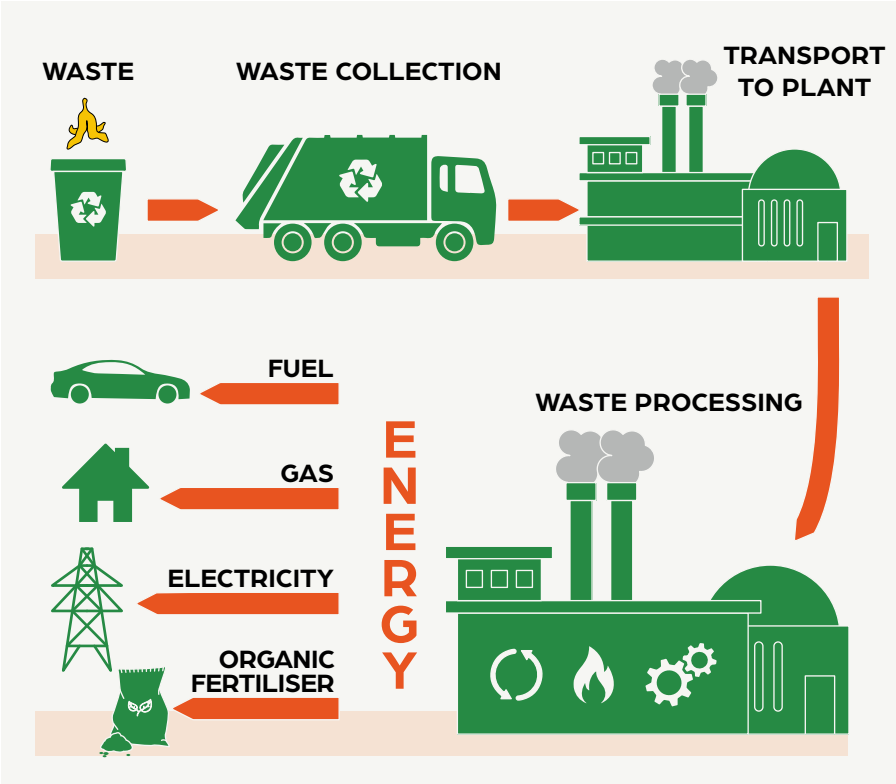
# 02 A PRACTICAL EXAMPLE OF THE CIRCULAR ECONOMY – BIOGAS

## SYNERGY OF BIOGAS AND THE CIRCULAR ECONOMY

In practice, the circular economy concept can be applied in various sectors, including energy, manufacturing, agriculture and waste management. One of the most important practical examples of the circular economy is the production of biogas, which enables the transformation of organic waste into renewable energy and biofertilisers, demonstrating how resources can be efficiently used and recycled.

As biogas is produced through anaerobic digestion of raw materials and organic waste, and all end products (heat, electricity, biomethane, and high-quality fertilisers) can be reused, this process is an ideal example of the circular economy.

In agriculture, the use of biogas is an excellent example of the circular economy. Residues from agriculture, such as manure and harvest residues, can be used as feedstock for biogas production. The process of anaerobic digestion not only produces electricity and heat and potentially biomethane (a substitute for natural gas), but also produces post-digestate that can be returned to the fields as high-quality fertiliser, thus closing the resource loop.




The production of biogas enables energy independence for both farms and the entire country, while reducing dependency on fossil fuels. By using biogas as a renewable energy source, farmers can significantly reduce their environmental footprint and contribute to the fight against climate change.

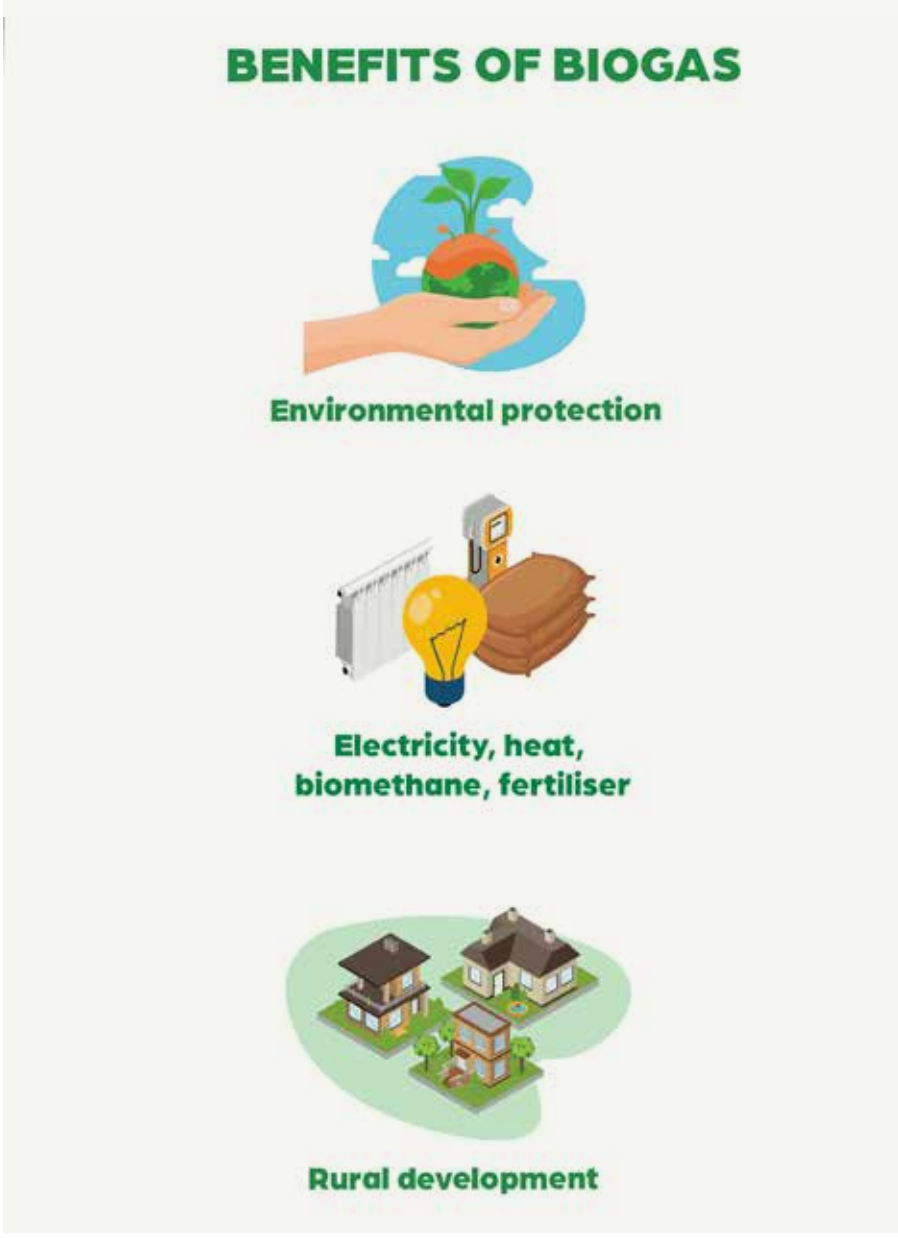
In addition to providing renewable energy and contributing to the preservation of the environment, biogas production plays a key role in waste management. Rather than organic waste ending up in landfills, where its decomposition would release methane and other greenhouse gases, it is used as a valuable resource, reducing the amount of waste and neutralising its negative impact on the environment.

In economic terms, the production of biogas contributes to local and especially rural development, job creation and reduction in waste management costs. Farmers and companies that invest in biogas plants can make significant savings and generate additional income by selling energy.

By including biogas as a key element in circular economy strategies, it is possible to address environmental, energy, agricultural and economic challenges at the same time, demonstrating how innovative solutions can transform waste into a resource and contribute to sustainable development.

## BIOGAS – A PRACTICAL SOLUTION TO TWO CHALLENGES IN MODERN SOCIETY – ENERGY SECURITY AND ENVIRONMENTAL PROTECTION

Biogas is the most complex and environmentally important form of renewable energy sources.




In simple terms, biogas is a mixture of gases, which is formed by the decomposition of organic matter under oxygen-free conditions (anaerobic conditions). The mixture of gases formed mainly consists of methane (50–75 vol%) and carbon dioxide (25–45 vol%). In addition, biogas contains small amounts of hydrogen, hydrogen sulphide, ammonia and other trace gases. This mixture of gases can be used to generate electricity and heat or biomethane.

At the core of the biogas production process is anaerobic digestion, the natural process of decomposing organic matter in the absence of oxygen. This process not only transforms organic waste into a useful source of energy, but reduces greenhouse gas emissions at the same time, thus directly influencing climate change mitigation.

Within global efforts to reduce dependency on fossil fuels and fight climate change, biogas stands out as a key player. Its ability to combine waste management with energy production makes it unique among renewable energy sources, thus **offering a practical solution to two challenges in modern society: energy security and environmental protection.**

# 02 A PRACTICAL EXAMPLE OF THE CIRCULAR ECONOMY – BIOGAS

## THE PROCESS OF OBTAINING BIOGAS

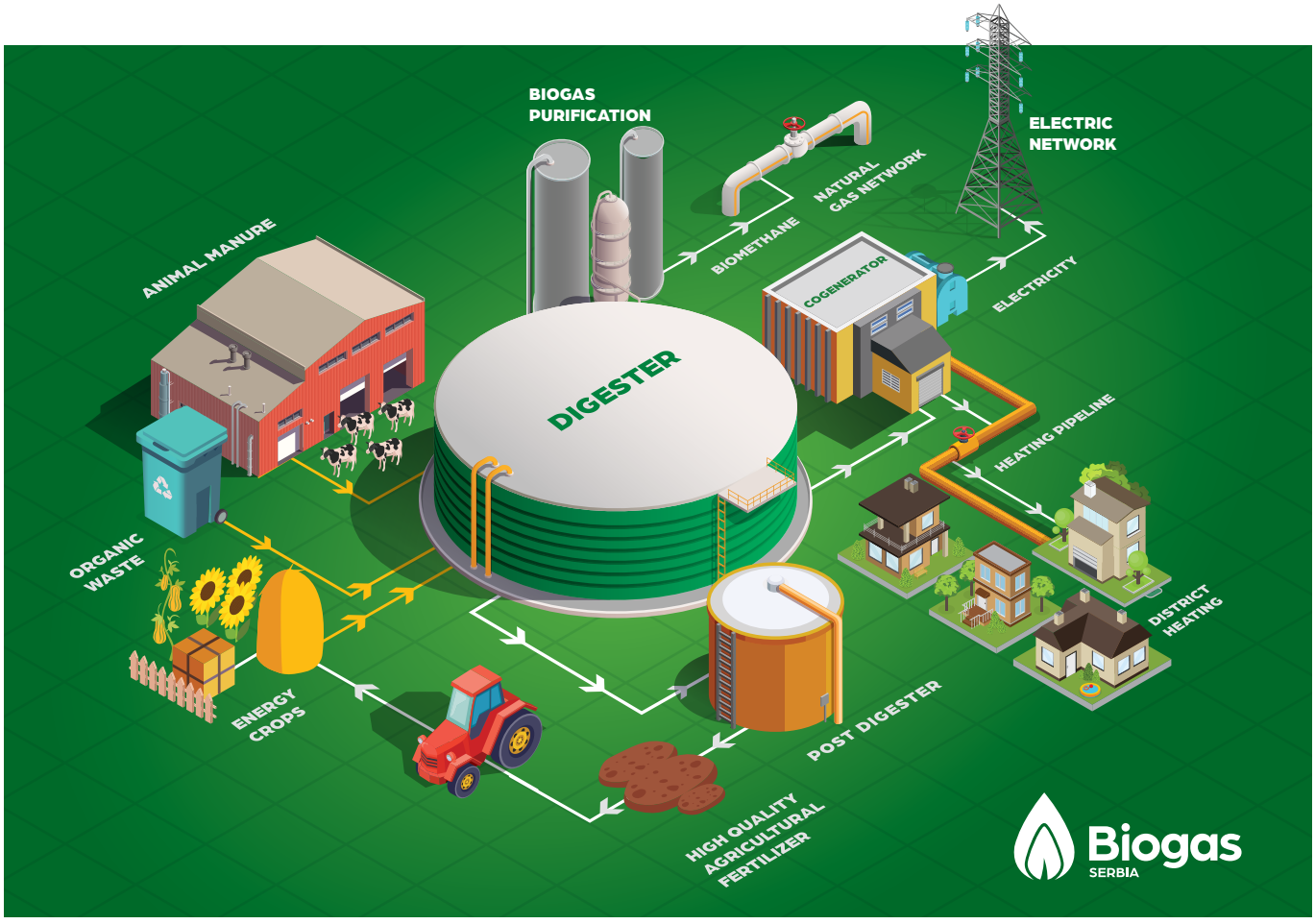
The production of biogas is a complex but extremely efficient process that takes place within specialised plants, known as biogas plants. This process is the result of a multidisciplinary approach involving experts from various fields: engineers, chemists, biologists, agronomists, veterinarians and ecologists, whose common mission is to optimise and effectively manage the biogas process.

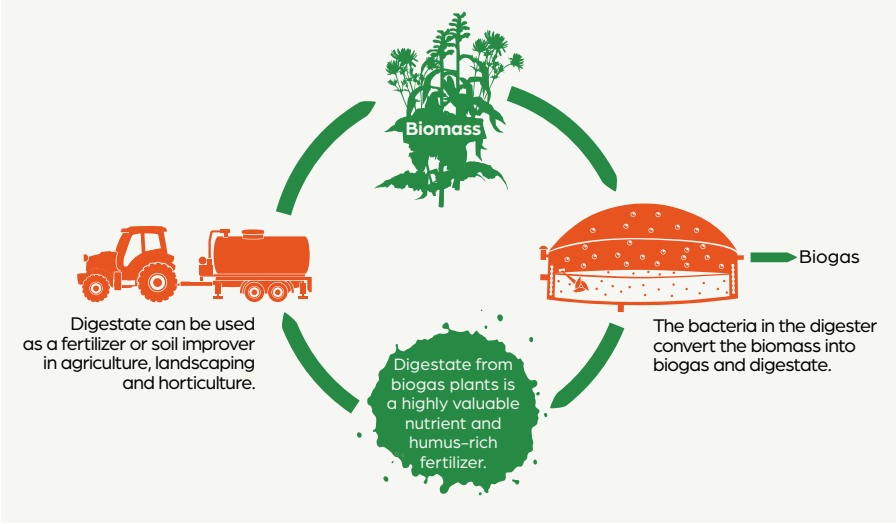
Anaerobic digestion, the core of the process to obtain biogas, is a biochemical process that takes place under oxygen-free, anaerobic conditions. Organic material, such as agricultural residues, municipal waste, wastewater and waste from the food industry, is converted into biogas under the action of specific microorganisms. Digesters, key elements of biogas power plants, are designed to provide the optimal conditions for this process to take place, keeping temperature, humidity and pH constant, thus maximising the efficiency of biogas production.

The process of obtaining biogas can be divided into several key stages:

**Pre-treatment:** This step involves the preparation and sorting of input materials, in which unwanted elements are removed and the material is shredded to increase the surface area for microbiological degradation.

**Anaerobic digestion:** At this stage, the prepared organic material is introduced into the digester, where microorganisms break down complex organic molecules (proteins, fats, carbohydrates) into simpler compounds, including methane and carbon dioxide, which make up the main components of biogas.





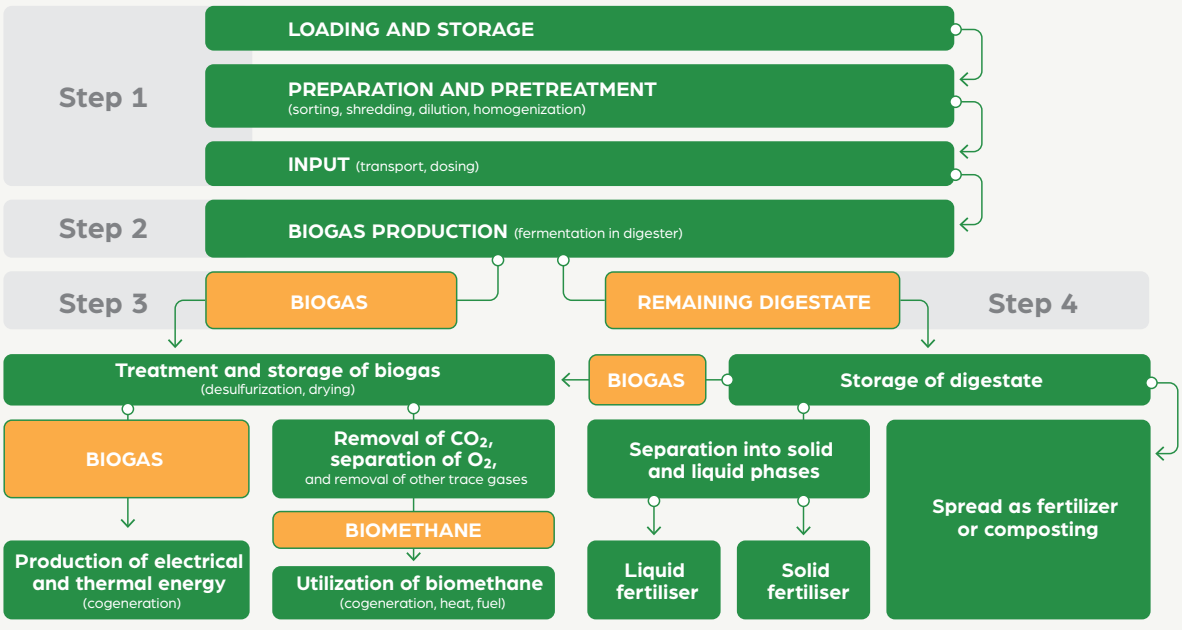

**Biogas collection:** The biogas produced is collected and purified before being discharged to a cogeneration unit, i.e. a biomethane production unit.

**Post-treatment:** Once the digestion process is complete, the remaining digestate undergoes additional processing processes, including dehydration and composting, resulting in output of high-quality fertiliser.

**Use of biogas:** The biogas produced can then be used directly to generate electricity and heat in cogeneration plants, purified to methane levels and used as a substitute for natural gas (biomethane), or used as fuel for vehicles.

**Power delivery:** Electricity produced from biogas is supplied to the power grid through appropriate substations, while thermal energy can be used for heating or in industrial processes.

## Biogas Process



# 02 A PRACTICAL EXAMPLE OF THE CIRCULAR ECONOMY – BIOGAS

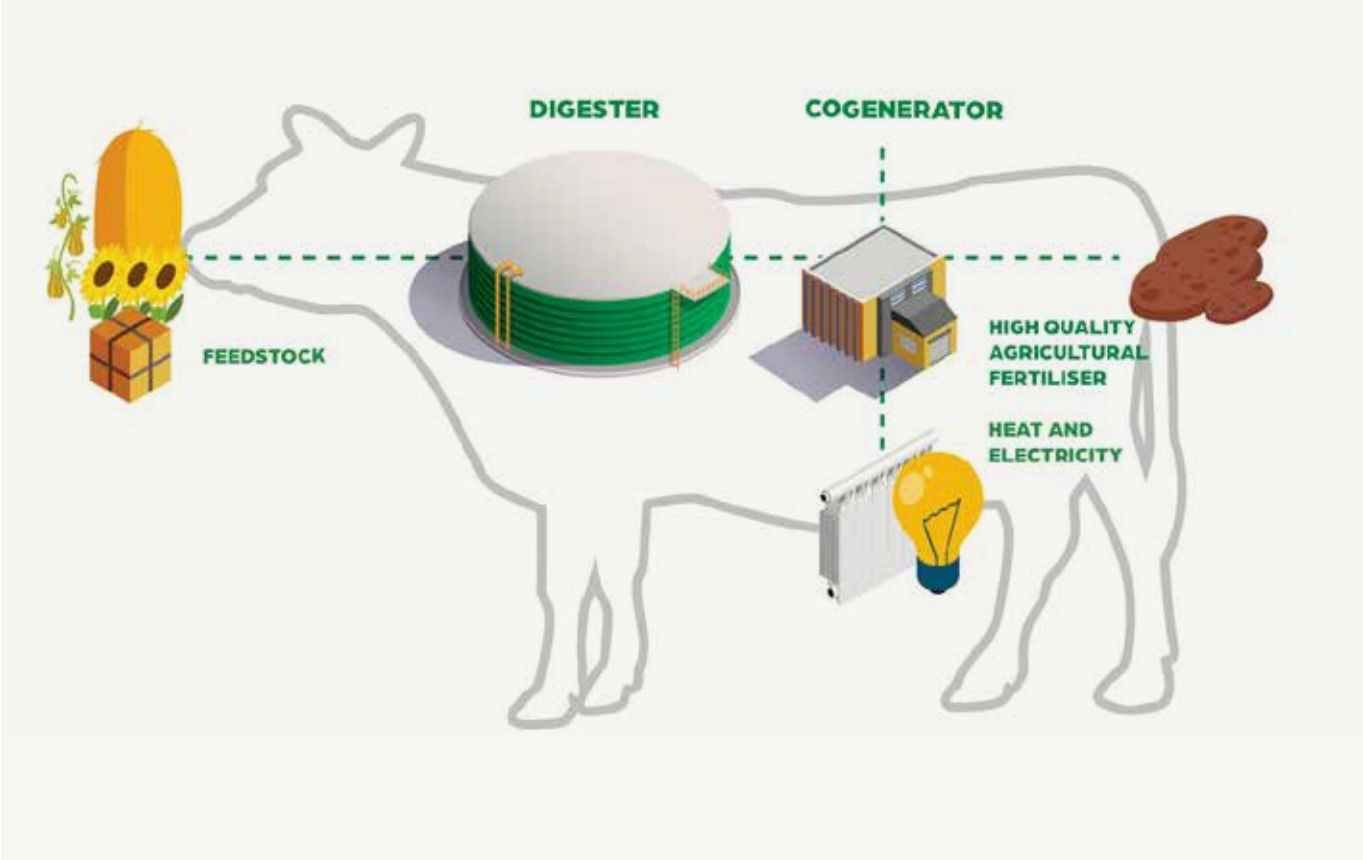
## STAGES IN OBTAINING BIOGAS

The process of the natural decomposition of organic matter results in the release of methane into the atmosphere. Covering organic fertiliser with plastic wrap permits collection of this release gas. Although this method may appear simple, a logical question arises – why are biogas power plants needed then?

In biogas plants, the biogas production process occurs under strictly controlled conditions. Making an analogy with the digestion process in the rumen of ruminants reveals significant similarities between biogas power plants and these biological systems.

Biogas production involves a multi-stage process that takes place through a series of coordinated stages. Under anaerobic conditions, the decomposition of organic material occurs, with proteins, fats and carbohydrates broken down through four stages. In the first, hydrolytic phase, the starting materials are converted into amino acids, fatty acids and sugars. This is followed by the acidogenic phase, in which these substances are further decomposed into acetate, hydrogen, carbon dioxide, short-chain fatty acids and alcohols. The third stage, known as the acetogenic or acetic phase, involves further decomposition to acetic acid, carbon dioxide, and hydrogen. Finally, methane and additional carbon dioxide are produced in the fourth methanogenic phase, methanogenesis.

The calorific value of biogas depends on the proportion of methane. Methane typically ranges from 50% to 75%. Carbon dioxide, ranging from 25% to 45%, ranks second based on its share. The share of water vapour is from 2% to 7%, with oxygen about 2%, and nitrogen about 1%. Hydrogen sulphide is also present and can range from 20 to about 20,000 ppm.



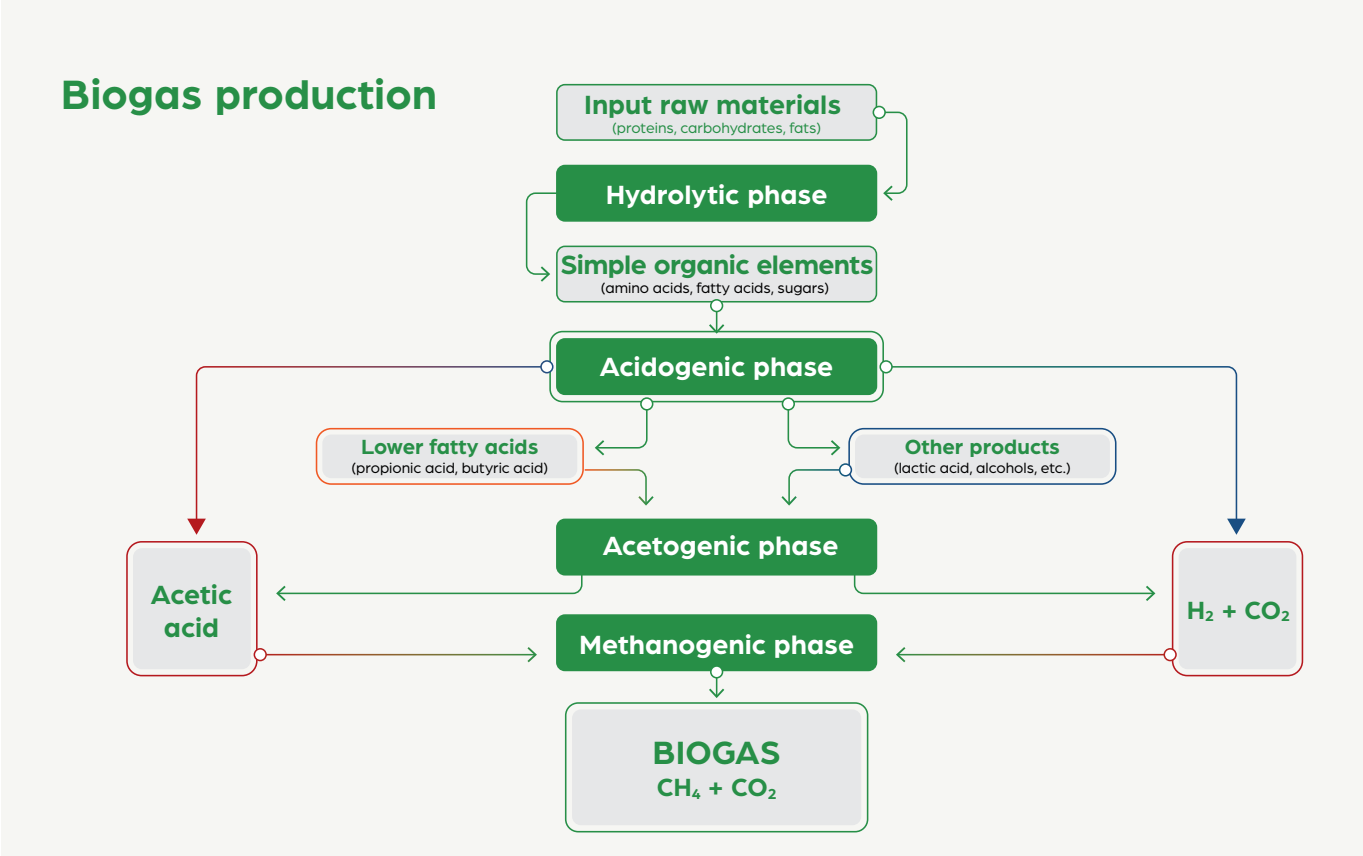
## RAW MATERIALS FROM WHICH BIOGAS IS PRODUCED

Biogas power plants operate on the basis of continuous intake of raw materials, the availability of which is imperative for the smooth operation of these plants.

Biogas technology uses a wide range of organic and biological waste, converting it into a valuable source of energy. In this context, agricultural residues, especially animal manure, constitute primary raw materials. Due to its composition, the presence of pathogenic bacteria and the potential for methane emissions, manure is considered to be a priority for processing.

Diversification of raw materials is crucial, so, in addition to manure, other plant substances such as corn silage, ground corn, grain silage, haylage, straw, sugar beet noodles, as well as by-products from the food industry such as oil sediment, jibra, molasses, whey, food waste and suchlike are used. Also, the use of slaughterhouse waste is possible on condition that it is pre-treated with pasteurisation in order to eliminate pathogenic microorganisms, which further confirms the multifunctionality of biogas technology in the management of different types of waste.

Financial institutions only provide credit support to investors who have their own sources of raw materials from their farms or have established stable contractual relationships with suppliers of raw materials. Without an adequate raw material, the concept of biogas production clearly becomes difficult to realise.



# 02 A PRACTICAL EXAMPLE OF THE CIRCULAR ECONOMY – BIOGAS

## BIOGAS POWER PLANT

Biogas power plants consist of a digester and a biogas conversion system. Digesters enable the generation of biogas from feedstocks, and biogas conversion systems convert biogas into useful forms of energy.

The retention time of the input raw materials in the digesters is between 30 and 60 days, but retention can be longer than 90 days in order to obtain a larger amount of biogas.

Biogas plants consist of a number of technical units: a raw material preparation and input unit, a biogas production and treatment unit, an electricity and heat or biomethane production unit and an electricity measurement and handover unit.

In terms of efficiency and stability, biogas power plants designed to operate in mesophilic conditions have made themselves the most optimal solution, thus they are the most widely found in Europe. The anaerobic digestion process there takes place at temperatures ranging from 38 to 42°C.

Digesters are hermetically sealed tanks, which are generally circular in shape. The volume of the digester depends on the capacity of the power plant and the type of raw materials envisaged for the production of biogas.

Investors may select technological approaches that involve the use of two or more digesters. Although such approaches offer advantages such as improved efficiency and easier operation of the plant, they significantly increase the initial investment costs and are not always economically viable.

To ensure that the raw material is evenly distributed within the digester, the digesters are equipped with mixers. Equal distribution of the raw materials is a key condition for successful production of biogas. In addition, in order to maintain a constant and uniform temperature within the digester during the production of biogas, it is fitted with heaters mounted on the inside. Temperature constancy is essential for the production of biogas, as the bacteria responsible for this process react negatively to any change in temperature.

To achieve greater efficiency in biogas production, digesters are equipped with additional equipment such as safety systems and inspection and automated control devices. This equipment also includes sensors for temperature monitoring, measuring the filling level of the digester, monitoring the amount of biogas produced, as well as valves for releasing biogas when it is necessary to reduce the pressure within the digester. The digesters are also equipped with inspection windows that allow visual inspection of the interior and monitoring of the process.

Once produced, biogas needs to be purified before further use, as, if this is not done, it could cause significant damage to the cogeneration units. The most important thing is to remove moisture and hydrogen sulphide.

Dehumidification is performed by cooling biogas, digging gas pipes into the ground, as well as by cooling devices. At the same time, a significant amount of hydrogen sulphide is removed by this procedure. If cooling and controlled air intake into the digester do not achieve satisfactory results in removing hydrogen sulphide, the installation of an activated carbon-based filter may be useful.

The refined biogas thus goes to the so-called "gas ramp", whose main role is to ensure constant pressure and constant flow of biogas into the cogeneration unit.

The cogeneration unit consists of an internal combustion gas engine, as well as an electricity generator. The internal combustion engine drives a synchronous generator, and electricity is thus generated.

Although biogas plants offer many advantages to investors, the main and greatest benefit to the investor is undoubtedly being able to sell the electricity. As the generator of the cogeneration unit provides voltage of 400 V at its output, it is necessary to match the voltage from the output of the generator with the voltage of the distribution network, so that the electricity can be delivered to the distribution network at

all, and then measure the amount of electricity delivered, for payment collection purposes.

The voltage of the distribution network to which transmission is made is usually 10 kV or 20 kV. The equipment used for voltage adjustment and measurement is, as a rule, situated in a substation located in the immediate vicinity of the biogas power plant itself.

Biogas technology stands out for its complexity, with the processes within biogas power plants designed to be inert, thus, in principle, fatal errors do not occur. In the event of a plant shutdown for any reason, a significant amount of time (about six months) is required for the process to resume, reach full operational capacity, and stabilise the microbial activity inside the digester. This further underlines the complexity of biogas technology, which requires detailed planning, expert management, and continuous monitoring to ensure efficient and safe operation.

Perhaps the most important thing to emphasise is that these plants are absolutely safe, and the conditions for obtaining biogas are completely controlled. Accidents cannot occur if the plants are operated according to the prescribed rules and in accordance with the operating guidelines provided by the equipment manufacturer. Accidents are unknown in our country, and the accidents that have occurred around the world are solely the consequence of failure by biogas operators and technical personnel operating the plant to comply with the safety rules.

# 02 A PRACTICAL EXAMPLE OF THE CIRCULAR ECONOMY – BIOGAS

## BIOMETHANE – THE FUTURE OF BIOGAS USE

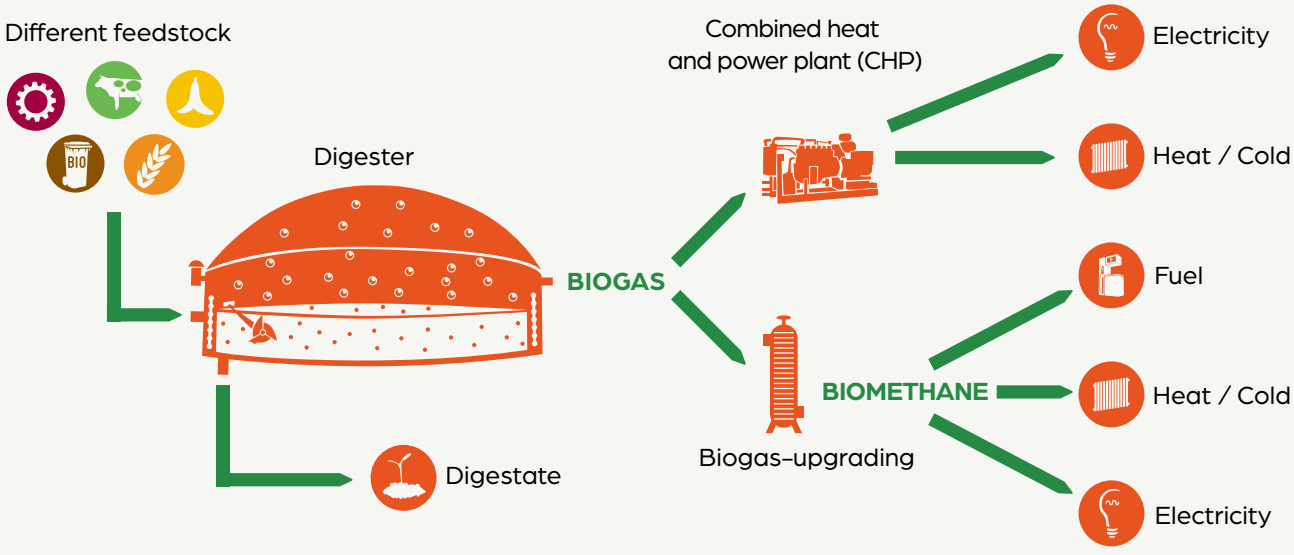
In addition to obtaining electricity and heat from biogas, the possibility of obtaining biomethane is extremely important, as it can fully replace natural gas based on its chemical properties. Given Serbia's resources in terms of raw materials for biogas production, biomethane, theoretically, can meet up to 100% of domestic natural gas needs. Serbia's biogas sector is still developing and there is currently no adequate legal framework for biomethane production, although the existence of such regulations is crucial for the sector's future. This would contribute significantly to reducing dependency on natural gas imports, while improving energy sustainability.

**How is biogas converted into biomethane?**

The process of converting biogas into biomethane can be explained most simply as the separation of methane from carbon dioxide. This further increases the methane content in the gas, to about 95–98%. As biomethane has the same chemical properties as natural gas, it can be fed directly into the grid.

The use of biomethane as fuel for vehicles requires the fulfilment of rigorous fuel quality criteria.

Due to the strict quality standards for biomethane, which include its use as fuel and its use in the natural gas distribution network, prescribed by national laws in all European countries, it is necessary to carry out mandatory pre-treatment processes.



## POTENTIAL FOR BIOGAS IN THE REPUBLIC OF SERBIA

In the Serbian biogas sector, much has been achieved in a short period of time and a favourable business climate has been created for investors.

To better understand the current situation in the biogas sector in the Republic of Serbia, as well as the importance of the sector for our country's economy and energy sector, it is necessary to look at the very beginnings of biogas in Serbia.

The first steps in the development of biogas in Serbia date back to the 1980s, when a total of seven active biogas plants were operating in the country. The largest of them were built on pig farms in Surčin and Vizelj. These plants did not benefit from state subsidies, but based their operations on the treatment of waste produced on farms and the production of electricity, heat and high-quality fertiliser for their own needs. Despite not being involved in the sale of electricity, the plants operated successfully until the introduction of sanctions in the 1990s, when the import of spare parts was suspended, thus making it impossible for them to operate.

Meanwhile, the Serbian biogas market was completely stopped, until 2009, when the Government of the Republic of Serbia prescribed the first set of incentive measures for the purchase of electricity produced from biogas. At that time, the regulation set the price in accordance with a plant's capacity, for a period of 12 years.

From then on, all investors in biogas could apply for the status of privileged producer of energy from renewable sources. Obtaining the status also included the possibility of signing a contract with JP EPS for a period of 12 years, during which time JP EPS undertook to purchase all the electricity generated by the plant.

In addition to preferential prices, this also provided a stable income for the biogas operator over a period of 12 years.

The first biogas plant with preferential status in Serbia was built in 2011 and, since then, the sector has seen exponential growth. Existing projects are being expanded and new ones launched, thus contributing to economic growth and job creation.

Given the possibilities for operation, i.e. the amount of easily available raw material for biogas plants, we can conclude that the potential in Serbia for biogas production is enormous. Serbia is traditionally an agricultural country, with more than 50% of its land area covered by agricultural land. Consequently, there is a large amount of residues from agricultural production for use as one of the raw materials that can be used to obtain biogas. If all of the above is taken into account, the future of biogas in Serbia is promising, with stable legislation. ■

# 03 WASTE AND WASTE MANAGEMENT IN THE REPUBLIC OF SERBIA

## WHAT IS WASTE?

Waste is defined as any material or object generated as a result of manufacturing, service or any other activities. This includes items that are excluded from further use, as well as waste materials that arise during the consumption process. A key characteristic of waste is that it is no longer considered by producers or consumers to be useful for its original purposes, which is why it must be discarded. However, waste is not necessarily useless. In a circular economy, especially in the field of biogas production, waste is considered to be a valuable resource.

In the biogas industry, waste is transformed from the status of unwanted material into a key raw material. Through anaerobic digestion processes, organic waste is converted into biogas, as well as into digestate, which can be used as a quality fertiliser. Consequently, waste that would otherwise be discarded and potentially cause environmental problems becomes a useful and environmentally-friendly product. This approach not only reduces the amount of waste that ends up in landfills, but also contributes to the reduction in greenhouse gas emissions, closing the material and energy cycle in accordance with the principles of the circular economy.

## WASTE MANAGEMENT IN THE REPUBLIC OF SERBIA

Waste management is one of the greatest environmental challenges the country has faced for decades. Insufficiently developed treatment and recycling systems, together with limited capacities for adequate waste disposal, have contributed to the accumulation of problems that have a negative impact on the environment, the population's health, as well as the country's economic development. Recently, this topic has gained greater visibility, with the need for sustainable resource management and environmental protection.

Serbia, like many other countries, faces challenges such as a lack of infrastructure for selective waste collection, outdated landfills that do not meet environmental standards, insufficient use of recycling technologies and low public awareness of the importance of recycling and reducing waste. These problems require urgent action and implementation of comprehensive strategies that would include the modernisation of existing infrastructure, promotion of the circular economy, as well as education of citizens about the importance of conserving the environment.

In order to improve the situation, it is necessary to adopt and apply more rigorous legislation that would encourage both companies and individuals to behave more responsibly towards waste. In addition, investing in new technologies for recycling, composting, as well as the development of waste-to-energy projects (such as biogas) could make a significant contribution to reducing the amount of waste that ends up in landfills.

Inspiration for solving the waste problem can be found in the practice of European countries, where, through the application of circular economy principles, waste is not treated as a useless residue, but rather as a resource that contributes to strengthening of the economy. In the European Union, almost half of municipal waste is successfully recycled, with landfilling considered as the last resort. By contrast, in Serbia, although 80% of municipal waste is systematically collected, a negligible percentage of it is recycled. This situation highlights significant potential for improvement through implementation of a circular economy.

The goal is to increase the waste recycling rate to at least 50 percent by adopting a circular economy model. In addition to the environmental and economic benefits, transition to a circular economy could create around 30,000 new jobs.

Although the public recognises the problem of waste disposal, the view is widely held that someone else is responsible for this issue – the state, local governments, industry. Public engagement often only occurs when people are directly affected by the

problem. Changing this attitude and getting greater involvement from citizens in waste management processes is key to a successful transition to a more sustainable and environmentally responsible future.

## WASTE AS A RESOURCE AND ITS ECONOMIC POTENTIAL

The concept of "waste as a resource" lies at the heart of the circular economy, marking a significant change in the way society approaches production and consumption. This approach leads us towards a model that sees waste not as a worthless item, but rather as a valuable resource ready to be reused, recycled, or converted into energy.


This innovative approach aims to close the resources loop, by continuously returning materials into use, instead of them being used once and discarded. This leads to significant reduction in the need to extract new raw materials, thus reducing the environmental footprint of production and consumption. By reducing the amount of waste that ends up in landfills or incinerators, this approach also contributes to the protection of natural habitats and the reduction in greenhouse gas emissions.

From an economic point of view, the circular economy paves the way for reducing the cost of materials for companies through more efficient use of resources. By reintroducing materials from waste into production chains, companies can reduce their dependency on volatile raw material markets and ensure more stable supply. In addition, the circular economy fosters innovation and development of new business models, such as sharing, repair and resale systems, creating new economic opportunities and jobs.

Industries focused on recycling and converting waste into energy are one of the fastest-growing sectors in the global economy. Through the creation of infrastructure for efficient waste management, from recycling centres to biogas plants, new jobs are created, which contributes to reducing unemployment and encouraging local economic development. In addition to direct employment, this sector also supports the development of related industries, including the production of recycling equipment, transport and logistics, as well as maintenance and management services.

In addition to direct economic benefits, efficient waste management can also contribute to greater energy independence. Converting waste into energy, such as producing biogas from organic waste, can reduce dependency on imported fossil fuels and contribute to the stability of the energy system. This practice also encourages the development of renewable energy technologies, which can further strengthen the economic opportunities in the field of green energy.

Furthermore, this model promotes more responsible consumer behaviour. Through greater awareness of the value of materials and waste, consumers can become key players in the circular economy, either by choosing products designed for long-term use and easier recycling, or supporting companies that apply sustainability principles.

Through promotion of the "waste as a resource" concept, it is possible not only to protect the environment, but

# 03 WASTE AND WASTE MANAGEMENT IN THE REPUBLIC OF SERBIA

to trigger a wave of economic innovation and growth. By investing in sustainable technologies, education and infrastructure, societies can pave the way to creating an economy that is not only environmentally friendly, but also provides long-term economic stability and prosperity. Therefore, the challenge of waste management should be seen as an opportunity for development, innovation and progress.

## THE 3R CONCEPT OF "REDUCE, REUSE, RECYCLE"

The 3R concept is an abbreviation for the three basic principles of sustainable waste management: Reduce, Reuse and Recycle.

**Reduce:** This principle refers to the reduction of waste generation at source, i.e. the reduction in the amount of products and materials used. The goal is to reduce the consumption of resources and the amount of waste generated, which can include buying products with less packaging, reducing the use of single-use products, or switching to more efficient production processes.

**Reuse:** This principle involves reusing objects or materials instead of dis-

carding them after a single use. This can include repairing and restoring items, as well as donating or selling items that are still in working order. The goal is to extend the life cycle of the product and reduce the need for new production.

**Recycle:** This principle refers to the process of converting waste into new raw materials or products for reuse. Recycling involves collecting, sorting, processing, and reprocessing waste to create new products or raw materials. The goal is to reduce the amount of waste that ends up in landfill and use resources more efficiently.

**This 3R concept** is the basis for sustainable waste management and contributes to the achievement of circular economy goals. Building these principles into everyday practice and policies can create a more sustainable society that uses resources more efficiently and reduces its environmental footprint. ■

# 04 THE FUTURE OF THE CIRCULAR ECONOMY

## HOW INDIVIDUALS, COMMUNITIES AND GOVERNMENTS CAN CONTRIBUTE TO THE TRANSITION TO A CIRCULAR ECONOMY

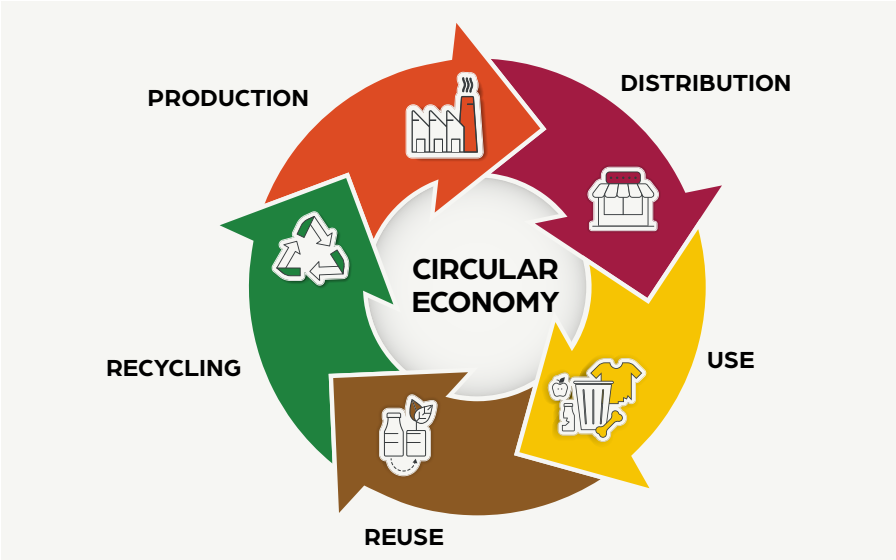
Making the transition to a circular economy involves a comprehensive change in the way we produce, use and manage resources, striving for a model that minimises waste and maximises the reuse and recycling of materials.

Here's how individuals, communities and governments can play their part in this process:

Individuals play a key role in the transition to a circular economy through everyday decisions about the purchase, use and disposal of products.

Changes that individuals can make include:

- Reduction in consumption: Thinking about the genuine need to buy new products and avoiding impulsive spending.
- Choosing sustainable products: Choose products designed for longevity, easily repairable, and made out of recycled or renewable materials.
- Reuse and repair: Use a repair shop or repair items on your own, rather than replacing them with new ones.
- Recycling: Proper waste separation and participation in local recycling programmes.




Communities can act as catalysts for change through collective initiatives and projects:

- Educational programmes: Organising workshops and seminars on the importance of the circular economy and how individuals can contribute.
- Local recycling initiatives: Supporting or establishing recycling and composting programmes at the local level.
- Joint consumer initiatives: Forming groups to jointly purchase sustainable products or services, thereby reducing the overall environmental footprint.

Governments have the power to set framework conditions for the transition to a circular economy, through the following actions:

- Legislation and regulation: Adopt laws and regulations that encourage the circular approach, such as product design standards, recycling obligations, and bans on certain single-use plastic products.
- Incentives for sustainable practices: Providing financial incentives for companies and start-ups that develop sustainable solutions and technologies.
- Investment in infrastructure: Creation of the infrastructure necessary for efficient waste management, including recycling and composting plants.

- Exchange of knowledge and technologies: Sharing innovations, best practice and technological solutions between countries.

- Joint initiatives and programmes: Work on joint projects and programmes that promote circular economic models on a global scale. Essentially, contributing to the transition to a circular economy requires a considered and coordinated effort by all areas of society. Through joint action, innovation and education, we can build a sustainable future that not only protects our planet and its resources, but also ensures welfare and fairness for all current and future generations. ■

## A CALL TO ACTION!

Today, when our planet faces many challenges, we have a noble task in front of us – to set about nature conservation with deep respect and genuine commitment. It is also our moral obligation, one of the highest, which has been entrusted to us all!

Taking responsibility for the protection and restoration of planet Earth is the only and most appropriate way to return the love and care that nature selflessly gives us.

At this critical time, when nature is grappling with the consequences of centuries of our unscrupulous behaviour, our commitment and actions can make a significant difference. We don't need to make big changes in behaviour and actions, as even the smallest change in our daily lives will have a big and far-reaching impact. Whether it's reducing the use of single-use plastics, committing to recycling, saving water, or planting new trees, each of these steps leads to a healthier and better environment. The contribution made by each of us is important, as planet Earth is our common home, and responsibility for its preservation lies with all of us.

A dose of optimism is instilled by the fact that we still have the chance to improve and put right everything we have been destroying in nature over the centuries with our unconsciousness, with the ultimate goal of leaving the world in a better condition for future generations. The vision of a greener and more prosperous future where nature and man live in harmony is achievable if we set about the common task of nature conservation with the utmost responsibility and urgency, making it our core mission to preserve the foundations on which all life rests. This is our chance to write a new story for humanity, a story of harmony, sustainability and mutual respect – a story that begins with each of us, here and now.

So, let's embark together along the path of responsibility and love for the planet, preserving it for present and future generations and giving it the gratitude and respect it deserves. ■

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