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## Biogas - renewable source of energy

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# BIOGAS – RENEWABLE SOURCE OF ENERGY

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**Abstract:** *Biogas is considered to be an important source of renewable energy, the production of which is on a continuous rise and which can be decisive for the elimination of fossil fuels by 2050. To reduce the negative impact of human actions on the environment, we must take measures urgent for stimulating the use of renewable energy but also for increasing awareness of the environmental crisis. The major cause of greenhouse emissions, but also of climate change, is also attributed to throwing food waste into landfills. This food waste, in addition to other plant and animal matter, constitutes an important raw material for obtaining biogas. The bioenergy thus obtained can considerably reduce greenhouse gas emissions. The production of biogas offers a multitude of advantages for the population of the whole world, for the environment and last but not least for the business environment.*

**Keywords:** *biogas, renewable energy sources, biofuels, energy policy*

**JEL classification:** Q2, Q20, Q28

## INTRODUCTION

Both environmental pollution and the galloping increase in the price of fossil energy resources require the integrated use of all forms of renewable energy in energy consumption. The distribution of renewable energy resources on the territory of our country depends on their physical and chemical properties. Romania has the necessary resources for the development of the energy system, a balanced and diversified energy mix. Thus, solar, wind and biomass energy resources are found in the plains and low hill areas in the south and southeast of the country, geothermal resources are concentrated in the west of the country, and in the mountain areas we find biomass and microhydro resources.

In 2020, Romania reached the EU renewable energy target of 24% of total energy consumption from renewable sources, for 2030 the target is set at 30.7%. According to the National Energy and Climate Plan, Romania's greenhouse gas emissions are expected to be reduced by more than 50% compared to the levels recorded in the 1990s by 2030. This can be attributed to the significant reduction of activities in the sector industrial, of increasing energy efficiency, but also of complying with environmental standards. All these targets, both those for renewable energies and those for reducing greenhouse gas emissions for the year 2030, will be achieved in accordance with the EU "Fit for 55" packages. The "Fit for 55" package refers to the EU's objective of reducing net greenhouse gas emissions by at least 55% by 2030 (European Council – Fit for 55, 2022). The proposed package aims to align EU legislation with the 2030 target. This package also contains a review of the Renewable Energy Directive. The proposal is to increase the current EU target of at least 32% of energy from renewable sources in the global energy mix to at least 40% by 2030.

## MATERIALS AND METHODS

The working materials used make direct reference to specialized scientific studies in the field and to the processing of related data as a result of the research carried out.

The methodology used in the work is determined by the targeted research field. Thus, the methodology used consisted of a selection of information sources regarding the evolution of the renewable energy sector, especially the use of biogas. The work is based on the analytical research method, after which the advantages and disadvantages of biogas were highlighted.

## RESULTS AND DISCUSSIONS

Romania's electricity mix is quite balanced, with comparable capacity and production rates, it currently includes all types of production that come from both conventional sources (coal, natural gas, fuel oil, etc.) and renewable sources (hydropower, wind and solar, biomass, etc.).

According to the report of the National Energy Regulatory Authority (ANRE) regarding the results of monitoring the electricity market, Romania's electricity production, in 2020, was achieved in proportion to 45.28% from renewable sources, and the remaining 54.72% from conventional sources. The document shows that, among renewable sources, hydroelectric plants provided 29.08% of electricity production, followed by wind (12.66%), solar (2.69%) and biomass (0.84%) installations. Among the conventional sources, we note that the Cernavodă reactors produced 20.19% of the total electricity production, followed by coal with a production of 16.51%. Natural gas provided 15.92% of the total production, and fuel oil, together with other conventional sources, 0.01% and 2.1%, respectively (Table no. 1).

**Table no: 1- Electricity production in Romania (%)**

No. crt.	The primary source of energy	2015	2016	2017	2018	2019	2020
	<b>Total, of which:</b>	100.00	100.00	100.00	100.00	100.00	100.00
<b>A</b>	<b>Conventional sources:</b>	58.46	57.62	61.80	58.72	57.83	54.72
a1	Coal	26.89	24.47	26.56	24,24	22.89	16.51
a2	Nuclear	17.83	17.49	18.11	17.65	18.98	20.19
a3	Natural gases	13.52	14.99	15,22	15.02	13.95	15.92
a4	tar	0.06	0.28	0.05	0.03	0.01	0.01
a5	Other conventional sources	0.16	0.39	1.85	1.78	2.00	2.10
<b>B</b>	<b>Renewable Sources:</b>	41.54	42.38	38.20	41.28	42.15	45.28
b1	Hydroelectric	27.36	28.86	23.42	27.87	26.75	29.08
b2	Aeolian	11.03	10,13	11.64	9.78	12.09	12.66
b3	biomass	0.71	0.75	0.57	0.47	0.68	0.84
b4	Solar	2.43	2.60	2.55	3.15	2.62	2.69
b5	Other renewables	0.01	0.05	0.03	0.01	0.01	0.01

Source: National Energy Regulatory Authority - EE market monitoring - Reports on the results of the electricity market monitoring for the month of December <https://www.anre.ro/ro/gaze-naturale/legislatie/documente-de-discutie/documente-de-discutie/legislatie/monitorizare-piata-ee> - accessed March 2022

The average CO2 emissions resulting from the production of electricity had the value of 213.37 g/kwh, decreasing by 40% compared to 2015 (Table no. 2).

**Table no: 2 - CO2 emissions at the level of Romania in the period 2015-2020**

No. crt.	The primary source of energy	2015	2016	2017	2018	2019	2020
1	Coal	898.76	910.73	911.14	915.60	881.04	853.76
2	Natural gases	411.07	395.90	407.04	386.35	375.52	388.78
3	tar	777.26	593.10	599.74	609.15	845.85	728.84
4	Other conventional sources	794.20	840.60	553.15	546.28	524.33	498.07
5	Renewable sources	0	0	0	0	0	0
	<b>Romania-wide average of specific CO2 emissions (g/kwh)</b>	299.02	287.11	314.52	289.85	264.69	213.37

Source: National Energy Regulatory Authority - EE market monitoring - Reports on the results of the electricity market monitoring for the month of December <https://www.anre.ro/ro/gaze-naturale/legislatie/documente-de-discutie/documente-de-discutie/legislatie/monitorizare-piata-ee> - accessed March 2022

The average specific values of CO2 emissions by type of primary energy sources are determined as a weighted average of the specific emissions achieved and the electricity delivered by each producer per type of primary source.

If we compare the direct emissions of greenhouse gases and other combustion gases resulting from the burning of various types of fuel, we can see that biogas is an "ecological fuel" (Table no. 3).

**Table no. 3: Direct emissions of greenhouse gases and other combustion gases (g/kwh)**

No. crt.	Fuel type	Equivalent CO2	Methane CH4	Carbon dioxide CO2
1	BIOGAS	2	0.008	0
2	Benzine	269	0	269
3	diesel fuel	282	0.001	277
4	Methane gas	201	0.003	199
5	Coal	344	0.324	335

Source: Biogas, the advantages of biogas, online: <https://focuseco.ro/wp-content/uploads/2016/02/biogaz-interior-final1.pdf>

Of the total energy production of 8565 MW (production registered in March 2022), approximately 55% was represented by renewable energy sources (Transelectrica, 2022). Of these, the largest share was held by wind energy production (26%), followed by hydropower (23%), solar (5%) and biomass (1%).

According to the National Energy Regulatory Authority (ANRE), the electricity production capacity owned by our country is 18545 MW (ANRE, 2022). Thus, in first place are hydropower plants with a capacity of 6644 MW (35.8% of the total), followed by coal plants with 3.092 MW (16.7%) and wind farms with 3014 MW (16.3%). Biomass is in 7th place with a production capacity of 106 MW (0.58%) followed by biogas with a capacity of 16MW (0.09%). (Table no. 4)

**Table no. 4: The total electricity production capacity in Romania**

No. crt.	Production type	MW value	% of total value
1	Water	6644.43	35.83%
2	Coal	3092.20	16.67%
3	Aeolian	3014.91	16.26%

No. crt.	Production type	MW value	% of total value
4	Hydrocarbs	2853.73	15.39%
5	Nuclear	1413.00	7.62%
6	Solar	1393.14	7.51%
7	biomass	106.89	0.58%
8	BIOGAS	16.97	0.09%
9	Waste	6.03	0.03%
10	Waste heat	4.10	0.02%
11	Geothermal	0.05	0.0003%
	<b>TOTAL</b>	<b>18545.45</b>	<b>100.00%</b>

Source: ANRE – Installed power in MW electricity production capacities <https://www.anre.ro/ro/energie-electrica/rapoarte/puterea-instalata-in-capacitatiile-de-productie-energie-electrica>- Situation as of 03/14/2022

Currently, Romania has a very good potential to ensure the generation of raw material resources for biogas production. Thus, our country has a great potential to produce biogas by using waste resulting from primary production, from solid urban waste, sewage sludge. From animal waste as well as from waste from food processing, the potential for biogas production is lower. This is due to the reduction of livestock numbers that affected the Romanian animal husbandry.

The table below shows the biogas yield (m<sup>3</sup>) that can be obtained from one ton of raw material. It is observed that the best yield for obtaining biogas is given by raw material resources from agriculture but also from waste from slaughterhouses (Table no. 5) (ANRE,2022).

**Table no. 5: Biogas production from agricultural and agro-industrial raw materials**

The raw material	Biogas yield (m3) from 1 ton of raw material
Lucerne, clover	430-490
Cereals and crop waste	390-490
Field waste after grain harvest	140-165
Corn silage	250-410
Vegetable waste	330-500
Vegetable and potato wedges	280-490
Field waste from beet harvesting	75-200
Pulp from beet sugar extraction	29-41
Vegetable table of herbs	290-490
Distillery rack from alcohol production	45-95
Cereal sediment from beer production	39-59
Milk whey	50
Slaughterhouse waste	240-510
Poultry waste	46-93
Cattle litter without litter	39-51
Cattle manure mixed with straw	70
Pig litter	51-87
Sheep farm litter	70

Source: AGROBIZNES.MD. Luminița Crivoi, How we produce biogas and thermal energy from agricultural waste, article accessed online: <https://agrobiznes.md/cum-producem-biogaz-si-energie-termica-din-deseuri-agricole.html>

The raw materials used in the anaerobic fermentation process can contain different biological, chemical or physical compounds: vegetable waste and manure can contain pathogens of the organisms from which they come, and household waste, organic waste from various food

industries, sewage sludge can contain substances biological, chemical or physical. Thus, a large amount of carbohydrates (C:N ratio>30), proteins (C:N ratio <10) or the presence of inorganic (trace elements, heavy metals, etc.) and organic (pesticides, disinfectants, detergents, etc.) inhibitors can inhibit and even stop the production of biogas.

The following table shows the list of waste suitable for biogas production included in the European Waste Catalog. This European Waste Code (European Waste Code) includes the list of waste classification codes according to Directive 75/442/EEC and applies to all waste, regardless of whether it is intended for recovery or disposal (Table no. 6) (EWC codes, List of waste, 2022).

**Table no. 6: Waste suitable for biogas production**

European Waste Catalog (EWC) code	Waste description
02 00 00  02 01  02 02  02 03  02 04 02 05 02 06  02 07	Ofeteurs from agriculturecomplicated, horticulturecomplicated, aquaculturecomplicated, forestrycomplicated, vencomplicatedharmfuletrand fishing, cookingetand food processing - Ofeteurs from agriculturecomplicated, horticulturecomplicated, aquaculturecomplicated, forestrycomplicated, vencomplicatedharmfuleti fish - Ofetyou from the preparationetand processing ccomplicatedwounds, onetfishetand other foods of animal origincomplicated - Ofetyou from the preparationetand the processing of fruits, vegetables, cereals, edible oils, cocoa, coffee, teaetand tobacco processing; from the productPtake canned goods; from the preparationetand yeast fermentationetand extracts on the basiscomplicatedof yeasts, molasses - Ofeteuro from processing zahcomplicatedthe evil - Ofeteurs from the dairy industry - Ofetfrom the bakery industryPieettake confectionery productscomplicatedlaugh - Ofeteurs from the industry bcomplicatedalcoholic drinksetand non-alcoholic (exceptPtake coffee, tea,etand cocoa)
03 00 00  03 01  03.03	Ofeteurs from woodworking, woodwork, carpentryetand from the productPpick up the phonecomplicatedcarpenter, producePpick up the phonecomplicated, the pulp industrycomplicated, paperetand cardboard - Ofeteurs from woodworking and from prodPtake panels and furniture - Ofeteuros from the productPtakesetand pulp and paper processingetand cardboard
04 00 00  04 01  04 02	Ofetfrom the leather industrycomplicateddriei, blcomplicatedcharmsetand textile - Ofetfrom the leather industrycomplicatedCity Halletand blcomplicatedcharms - Ofeteurs from the textile industrycomplicated
15 00 00	Ofetpackaging type, absorbentPcloths for the assACROSSat, materials

European Waste Catalog (EWC) code	Waste description
15 01	filteretand roomcomplicateddcomplicatedmind to protectPie, not specified elsewhere - Packaging (including those sorted for collection from the use of I wouldeneetype of packaging)
19 00 00  19 06 19 08 19 09	Ofetfrom the installationPiiles of management ofetto them, ofeteurs evacuated by ccomplicatedthree plants for treatment wastewateretand for the preparation of drinking waterettake water used in industry - Ofetemissions from the anaerobic treatment of residues - Ofetsewage from sewage treatment plants, not elsewhere specified - Ofetemissions from the preparation of water intended for human consumption or water for industrial use
20 00 00  20 01 20 02 20 03	OfethoursI wouldeneetti (from the householdcomplicatedcountryetand others like itetwaste traderetand industrial) including ofethe ones sorted for collection - tailsPiile of ofeteuros collected separately (except 15 01) - Ofeteuros from grcomplicatedteethetand parks (includingetcemeteries) - Other ofethoursI wouldeneetyou

Source: EWC codes, List of wastes, European Waste Codes, <https://www.pureplanetrecycling.co.uk/list-of-waste/>

Biogas is considered to be an important source of renewable energy, the production of which is on a continuous rise and which can be decisive for the elimination of fossil fuels by 2050.

In order to reduce the negative impact of the actions taken by people on the environment, we must take urgent measures to stimulate the use of renewable energy but also to increase awareness of the environmental crisis. The major cause of greenhouse emissions, but also of climate change, is also attributed to throwing food waste into landfills. This food waste, in addition to other plant and animal matter, constitutes an important raw material for obtaining biogas. The bioenergy thus obtained can considerably reduce greenhouse gas emissions.

The main advantages and disadvantages of biogas are (Berevoianu, 2022, Teodorita Al Seadi et al., 2008):

### ADVANTAGES OF BIOGAS

<i>It is ecological, non-polluting in nature</i>
<p>Being a clean source of energy, the biogas generated by biodigestion is not polluting. In this process, where microorganisms break down biodegradable materials in the absence of oxygen (no combustion occurs), there are no greenhouse gas emissions into the atmosphere. Thus, by using biogas as an energy source, global warming is significantly reduced.</p> <p>However, carbon dioxide is produced both following the process of anaerobic digestion (biological decomposition) and during the use of biogas. But, the amount of carbon dioxide released from the production of biogas is much lower than the amount of carbon dioxide produced from burning fossil fuels. The amount of carbon dioxide released into the atmosphere following the use of biogas is equal to the amount needed for the plant growth process, which in a way leads to its balancing in the</p>

atmosphere. Therefore, biogas can be considered as a green and clean energy source because its combustion does not cause harmful emissions of greenhouse gases and reduces environmental pollution. The biogas production process is a natural one. Biogas plants capture methane gas (the main contributor to the greenhouse effect) and use it as fuel. Therefore, the production of biogas helps to significantly reduce the greenhouse effect and dependence on the use of fossil fuels.

*It is a renewable source of energy*

The basic raw materials needed to supply biogas production facilities are represented by organic materials derived from plants, animals and humans. Thus, crops and trees will continue to grow and agricultural residues, food and livestock waste will always be available. This makes biogas a renewable energy source.

Also, the use of waste as raw materials for the production of biogas reduces their inappropriate disposal as well as the negative impact on the environment. Based on these statements, we can conclude that biogas production can be a sustainable option.

Due to the fact that it is produced from renewable sources, biogas is reliable. For example, other renewable energy sources (solar and wind) depend on certain weather factors to produce electricity continuously. Biogas production can be carried out continuously regardless of weather conditions.

*Reduces soil and water pollution*

Soil pollution directly affects water and air quality. The most common causes of soil and water contamination are those resulting from human activities: waste and waste water management, agriculture, animal husbandry, etc. The use of biogas contributes to a fairly important extent to the reduction of soil and water pollution and, implicitly, of the environment.

Landfills are considered to be one of the biggest sources of pollution with a major negative impact on the environment. These waste deposits, also called landfills, influence soil fertility and quality, pollute surface waters, and alter air quality and the surrounding landscape.

Landfills, in addition to emitting unpleasant odors, allow toxic liquids that are released as a result of decomposition processes to seep into the underground water table, poisoning and polluting water and soil. Therefore, separating organic waste from garbage to produce biogas greatly reduces the amount of waste in landfills. Also, by generating biogas, water quality can be improved. Pathogens and parasites are deactivated through the process of anaerobic digestion, a process quite effective in reducing the incidence of water-borne diseases.

At the same time, in the areas with biogas installations, the collection and management of waste is significantly improved, which determines a control of water and soil pollution to a certain extent.

*It prevents health problems and the destruction of biodiversity*

Due to the diversification of human consumption, the rate of waste disposal in landfills is increasing. This leads to the construction of more landfills, which requires the clearing of wild areas that provide ecosystem services and habitat to a fairly significant number of plants and animals.

As it was mentioned above, following the decomposition process of waste from storages (landfills), both toxic materials are released into the ground and methane – a greenhouse gas that affects both human health and flora and fauna. This mixture of toxins causes health problems for human and animal populations but also in the ecosystems around them. In areas with biogas installations, it was found that waste is collected and managed much more responsibly, which leads to the improvement of the natural environmental conditions, sanitation and hygiene of the areas, but also to the reduction or elimination, where possible, of pollution and pollution sources.



*Reduces the amount of waste in landfills*

Large amounts of waste from landfills have a negative effect on the environment due not only to unpleasant odors but also to toxic liquids that seep into the soil, easily reaching underground water sources. This waste, instead of being left to rot in landfills, can be used and converted into energy for use in heating, electricity, cooking and as fertiliser. Biogas production can be considered as an advantageous method of using waste and turning it into an energy source. At the same time, by transforming waste into biogas, the amounts of carbon dioxide, methane and other greenhouse gases are significantly reduced. By consuming waste from landfills to generate biogas, the amount of stored waste is reduced, thus there is a decrease in water and soil pollution. In conclusion, the harmful impact of landfill waste is reduced and the problem of improper waste disposal is solved.

*It produces organic fertilizers*

The generation of biogas through anaerobic digestion is considered to be the optimal method by which a wide variety of wastes, which can lend themselves to this purpose, can be transformed into renewable energy and organic fertilizers for agriculture.

The by-product resulting from the process of obtaining biogas is a natural fertilizer called enriched organic digestate, which is considered to be a complete supplement that can replace chemical fertilizers. These fertilizers are effective in accelerating plant growth and disease prevention and resistance, compared to chemical fertilizers that can have toxic effects on both plants and humans.

*Minimizes over-reliance on fossil fuels*

Fossil fuels pollute the environment, are non-renewable and unsustainable and the process of obtaining them is a dangerous one. Biogas generation reduces dependence on the use of fossil fuels (oil, coal, etc.), being one of the clean and sustainable energy options.

*Alternative energy source*

In areas with limited access to energy sources, biogas can be a good alternative for electricity and fuel. Natural gas can easily be replaced by biogas for: heating, cooking, vehicle fuel, electricity, steam generation, pipeline gas, etc.

The use of biogas as a fuel for food preparation has the advantage that household members are relieved of the burden of collecting firewood, food preparation is no longer done over an open fire, which leads to a reduction in household air pollution due to the inefficient use of solid fuels. Thus, biogas is both a safe alternative for domestic use and a cheap alternative.

*Biogas production technology is cheap and economical and favors the development of a circular economy*

When used on a small scale, the technology for biogas generation is quite cheap because it does not require large investments and can be easily set up. These installations lend themselves very well to rural areas, and the biogas production obtained is intended for personal use in rural households, and production costs are also minimal. The biodigesters used are of small capacity and can be used in individual households. The materials used to produce biogas are free and come from both kitchen waste and animal waste. This waste is transformed into biogas which can be used for electricity and heating, natural gas for cooking but also digested as fertilizers. In this way,

*Opportunities for green job creation*

In rural areas, thanks to the installation of biogas plants, the opportunity to create green jobs appears. These green jobs contribute to the protection of biodiversity and ecosystems, to the minimization or total

avoidance of waste production and pollution. In most countries where biogas plants are quite large, jobs have been created especially in the field of waste collection and biogas production.

### **THE DISADVANTAGES OF BIOGAS**

#### *It contains a number of impurities*

Even if before use the biogas goes through several refining and compression processes, it can contain a series of impurities that can be harmful to the components that come into direct contact with this gas. Among the impurities that can be found in biogas we mention: siloxane impurities that can cause damage to processing equipment when they are burned; the level of sulfur impurities is determined by the nature of the raw materials used for biogas generation; impurities with terpenes (isoprenoids) that appear due to the nature of the material from biological sources; ammonia and impurities with volatile hydrocarbons such as benzene, toluene, ethylbenzene, xylene. These impurities, during the combustion process, accumulate on the heated surfaces in the combustion equipment. If the generated biogas has been used to fuel automobiles, it can lead to corrosion of the metal parts of the engine. The presence of impurities can mask the odor of typical sulfur additives, thus presenting a health and safety risk. They are also capable of causing the degradation of polymer materials for gaskets used in gas pipelines. Therefore, this disadvantage would lead to increased maintenance costs. Thus, biogas is much more suitable for use for cooking, water heating boilers, lamps.

#### *It is a flammable gas*

Biogas is a flammable and explosive gas containing up to 55-75% methane. During burning it forms a blue flame. If mixed with air at 10-30% there is a danger of explosion, so it must be handled with care.

#### *Biogas generation plants emit unpleasant odors*

Due to the concentration of unpleasant odors around the biogas generation facilities, it is recommended that these plants be built far enough away from residential areas.

#### *Biogas production is influenced by temperature*

In the biogas generation process, both the operation of the production facilities and the principles of fermentation and the necessary temperature conditions must be taken into account. In optimal temperature conditions (37°C), the bacteria responsible for biogas production become much more active and the gas is produced at a faster rate. In areas with lower temperatures, digesters require a source of thermal energy to facilitate anaerobic digestion, thus maintaining a constant supply of biogas.

#### *The technologies used in biogas generation are little developed*

The systems used to generate biogas are not efficient enough because the technologies used are not new and the costs for simplifying the processes involved in its production are not reduced at all. Currently, most countries support the development of other established energy sources, namely: hydropower, solar, wind, etc. To increase the biogas production capacity, additional research is needed to develop new technologies that simplify the gas production steps.

#### *Biogas plants cannot operate in metropolitan areas*

Biogas plants are generally located in areas far from metropolitan areas because they require fairly large amounts of raw materials. These raw materials are predominantly found in rural areas that can permanently ensure the supply of waste (agricultural, livestock, food, etc.). It should also be mentioned that these biogas plants emit unpleasant odors from the waste, so that these biogas plants are very suitable for rural and suburban areas

## CONCLUSIONS

Biogas is a mixture of biogenic gases resulting from the fermentation or gasification processes of some organic substances. As a renewable energy source, biogas differs from natural gas because it is a biological product produced through anaerobic digestion, compared to a fossil product that is obtained through geological processes.

The most used raw material resources for the production of biogas come from: waste and secondary agricultural products, organic waste from the food industry and agro-industry (vegetable and animal), manure, household and catering waste, restaurants (vegetable and animal) , sewage sludge, energy crops (maize, sorghum, clover, *Mischantus*).

The production of biogas offers a multitude of advantages for the population of the whole world, for the environment and last but not least for the business environment. Compared to fossil fuels, biogas is a much more sustainable option because using it reduces the impact of methane on the climate, turning it into CO<sub>2</sub>, which is much less powerful as a greenhouse gas.

Biogas is environmentally friendly and for this reason it is also called "green gas". Even though biogas is natural, it can also be produced artificially in biogas plants, allowing the continuous and infinite creation of green gas, which can then be harnessed and used as a green energy resource.

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