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PRODUCTION OF ENERGY AND AGRIBIOCHAR WITHOUT RESIDUES AND WITH NEGATIVE CARBON FOOTPRINT WITH CHAB AND CHPAB CONCEPTS FROM THE ANNUAL RESIDUAL VEGETABLE AGRICULTURAL BIOMASS FROM ROMANIA

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Abstract: Agriculture is and will be a permanent source of food and residual biomass, but also an energy consumer with high GHG emissions. In Romania 2018 agriculture consumed 6.05 TWh energy with an emission of 18.32 Tg.CO2e and at a collection level of 67% could be obtained 21Tg.db dry residual vegetable agricultural biomass with an energy potential of 100 TWh, energy resource untapped. With micro–gasification processes CHAB and CHBAP from chopped and from agripellets with a lot of ash that cannot be burned efficiently, Energy and Biochar are produced without residues and with negative carbon footprint. Biochar is also usable as an efficient agricultural amendment with which economically and safely sequester CO_2 compared to known processes and with heat, that can be stored more efficiently than power, power is produced – when and as needed – and with negative carbon footprint. In a plant with CHAB concept from a 1 tonne of dry residual biomass is produced on average 2.5 MWht of heat and 200 kg of biochar with a minim negative carbon footprint of –400 kg.CO_2. Annually, from 20 Tg of agro–pellets with CHAB plants is produced 4 Tg of biochar and 50 TWh of thermal energy and 5.25 Gg of diesel will not be burned, having as ecological effect a negative carbon footprint of –18.25 Tg CO_2/year which offsets by 25% the CO_2 emissions of RO agriculture. CHBAP plants produce thermal and electrical energy with a cogeneration index of 5% and an almost zero carbon footprint with very low heat storage capacities and accumulator batteries. The fully automated CHAB and CHABAP plants is easy to uses by operators with medium training, contribute to increasing the level of employment in rural areas, contributing to the decarbonization of the Romanian economy in a GNDE requirements.

Keywords: residual biomass, agripellet, biochar, heat, power, CHAB, CHBAP, carbon footprint

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1. INTRODUCTION

Agriculture, industry, transportation and home heating consume energy. All low or negative carbon resources must be used.

On 11 December 2019, the European Commission presented the European Green Pact, a roadmap designed to ensure the sustainability of the European economy, by turning climate and environmental challenges into opportunities in all policy areas and by ensuring a fair transition for all and favorable to the inclusion of all.

The EU executive has set itself the goal of reducing greenhouse gas emissions in the European Union by at least 40% by 2030 compared to 1990 levels. Agriculture is responsible for about 10% of total GHG emissions in Europe and 17% in Romania.

The statement "negative emissions" is based on the error that bioenergy is primarily carbon neutral, but Life Contribution Assessment (LCA) conclude that the production of biofuels, biodiesel and bioethanol, produces even more GHG emissions than the fossil fuels they replace (Environment Agency Austria, 2017). Experiments show that emissions from biomass combustion are very high at the point of energy production and in GNDE this activity will no longer be supported.

Agriculture produces food biomass and residual agricultural vegetable biomass (RABM) that can be collected and recovered for energy production and biochar with a negative CO_2 footprint. The paper estimates the mass and energy potential of RABM collected annually as well as the production methods of thermal energy, biochar and electricity with negative carbon footprint and economic and social efficiency.

2. MATERIAL AND METHOD

— Energy potential of residual agricultural biomass

Vegetable crops have as main objective the production of food biomass (Bal), and as a by–product a large amount of residual biomass (Bmr) is obtained which a lot of carbon fixed by photosynthesis. Usually this residual biomass is totally or partially incorporated in the agricultural soil to increases the organic mass. But only 2–3% carbon remains in the soil, the difference returns to the atmosphere as CO_2 and CH_4.

Dry vegetable residual agricultural biomass (Bmr.db), with a high carbon content Cbm > 44%, is a large energy resource, renewable annually, which can be used for the production of thermal energy, electricity and AgriBiochar with a low or negative footprint of CO_2e. The achieved LCA confirms that zero or negative emissions can be produced, which ensures for other processes in agriculture and the food industry a compensation of emissions produced by energy consumption with a high positive footprint, especially from transport, contributing massively to decarbonization (low–carbon processes).

In 2018, the vegetal agricultural production in Romania was carried out on 6.85 million ha, 36.72 million tons of food biomass were produced and about 21 Tg.bmr.db dry residual biomass could have been collected with an energy potential of 100 TWh / year; to a very small extent capitalized. (Table 1)

Table 1 . Estimation of annual dry residual agricultural biomass potential (SoftEROL2020 ®)

Culture	Food biomass production			Residual dry biomass collected (Kcol=0,67)		Energy potential		Carbon content in BMR	
	Tg.bmf / year	ha/year	Mg.bmf / ha	Mg.bmr / ha	Tg.bmr / year	MWh / Mg.bmr	TWh / year	Mg.C / Mg.bmr	Tg.C / year
Corn	18.664	2441646	7.644	6.345	10.333	5.12	52.903	0.437	4.515
Autumn wheat	10.144	2116351	4.793	2.876	4.059	4.80	19.486	0.434	1.762
Sunflower	3.063	1007133	3.041	4.562	3.064	4.80	14.708	0.475	1.456
Rape	1.611	633215	2.544	5.851	2.471	4.67	11.541	0.460	1.137
Soy	0.466	169436	2.748	4.397	0.497	5.00	2.484	0.460	0.229
Tomato	0.743	53900	18.236	9.118	0.328	5.14	1.685	0.474	0.155
Wine grapes	1.144	177494	6.447	1.934	0.229	5.32	1.218	0.450	0.103
Peas	0.172	120200	1.435	1.722	0.138	5.40	0.746	0.460	0.064
Apple tree	0.425	53900	7.876	2.757	0.099	5.37	0.532	0.477	0.047
Plum tree	0.314	65900	4.762	1.429	0.063	5.42	0.340	0.480	0.030
Beans	0.017	11712	1.477	2.363	0.018	5.10	0.094	0.457	0.008
Total RO	36.762	6850886			21.300		105.737		9.506
Average				3.109		4.96	15.434	0.446	

The annual average of 3.1 Mg.bmr/ha containing 1.387 Mg. carbon and 15.43 MWh energy are significant values for the energy potential available in agriculture and decarbonization actions.

The main crop producing residual energy biomass is corn which has the highest energy efficiency followed by wheat and sunflower, together producing about 50 % of total energy potential.

Energy and other resources are consumed for vegetable agricultural production and food and residual biomass is obtained, with a positive carbon footprint of 5–17 (kg.C / MWh.bm). In 2018, RO agriculture consumed 6.05 TWh of energy with an emission of 18.32 Tg.CO_2e (Murad E., 2020; www.bioenergyeurope.org).

GHG emissions are usually allocated to food biomass which is the main product of agricultural crops. If all the emission is transferred to the residual biomass the footprint is 9 – 38 kg.C / MWh.bmr, much lower than the carbon content of at least 400 kg.C / MWh.bmr (Murad E., 2020; www.bioenergyeurope.org).

RABM collection and processing, shredding and pelletizing with modern technologies, increases CFPex external footprint by an average of 6 kg.C / MWh.bmr for pelleting and by 3.5 kg.C / MWh.bmr for shredding. RABM non–woody – stems, sticks and shovels are harvested, chopped, dried and pelleted. RABM woody – vine cuttings, fruit cuttings, seed and fruit peels, harvested, chopped and dried (Murad E., 2020; www.bioenergyeurope.org).

Processed biomass is stored as a usable energy reserve when and as needed, compared to energy produced from wind and photovoltaic cells that require very large storage capacities. The energy density of the agripellets stock is on average 2.7 MWh / m3, three times lower than that of diesel.

Non–wood residual agricultural biomass, from corn, wheat, sunflower, soybean, etc., which represents over 85% of the annual potential, contains 3–6% ash and a higher alkali content. These pellets are not recommended for combustion plants because they produce corrosion and have a low ash vitrification temperature <1000 degrees C. Energy recovery can only be done by pyrolysis and gasification procedure at temperatures <900 C.

— Carbon capture and sequestration technologies

The study (Livermore National, 2020) presents actual and future technologies with negative emissions for the two ways of capturing CO_2 from the atmosphere – through photosynthesis and chemical procedures.

Table 2. Costs for carbon sequestration technologies (Lawrence Livermore National, 2020)

Total System Costs in 2045 for 125 million tons of CO_2 removed from the atmosphere.			
Scenario/Basis	Total Mitigation (MtCO2/yr)	System Total Average Cost ($/ton CO2)	System Total Cost ($Billion/yr)
Gasification Scenario — negative emissions basis	125.0	65	8.1
Gasification Scenario — avoided emissions basis	183.2	44	8.1
Pyrolysis Scenario — negative emissions basis	125.0	112	14.0
Pyrolysis Scenario — avoided emissions basis	171.6	82	14.0
Combustion Scenario — negative emissions basis	125.0	81	10.1
Combustion Scenario — avoided emissions basis	125.0	81	10.1

LCA analysis of CO_2 capture and storage systems with chemical procedures indicates that the energy balance is uncertainly positive, which may lead to a positive increase in GHG emissions. It is found that gasification provides the lowest cost of CO_2 sequestration. Biochar carbon sequestration is evaluated as a technology applicable now and in the future, involving even the lowest costs (Lawrence Livermore National, 2020). (Table 2)

Another sensitive aspect is that sequestered gaseous CO_2 can be used in other processes only if it is very pure, which greatly increases the cost of sequestration.

According to the European Biochar Certificate (EBC version 6.5 August 2018) BioChar is defined: BioChar (BC) is a heterogeneous substance rich in aromatic carbon and minerals. It is produced by pyrolysis of biomass obtained sustainably under controlled conditions with clean technologies and is used for any purpose that does not involve its rapid conversion to CO2 and can be used as a soil amendment, also having the definition of AgriBiochar (AgBC) (Conte and Schmidt, 2021; Weber and Quickerb, 2018; EBI, 2020).

Many recent studies have found beneficial effects in the use of AgriBiochar an agricultural amendment in 58% of cases, and in 37% no difference (Baniasadi et al., 2019; Kammann et al., 2017; Quiang et al., 2020; Schmidt et al., 2021; Wang et al., 2015).

A recent statistical meta–analysis of the overall results of the use of AgBC as an agricultural amendment mentioned a positive effect of 13% increase in agricultural production and + 20% for water use efficiency. The authors used data from extensive and quality studies focused on the impact of biochar use based on factors such as: soil pH, soil type, fertilization doses, biomass from which BC is produced and the type of crop (Schmidt et al., 2021).

The obtained biochar has characteristics dependent on the biomass from which it was produced and on the thermal energy conversion regime. These different qualities must be correlated with the agricultural soils for which they are beneficial. Since 1984, Japan and since 2013, Switzerland and Sweden have officially approved the use of AgBC as an agricultural amendment. The approval is based on strict scientific verifications of the sustainability of Biofuel production, the quality of Biofuel and the protection of those who have used it.

An emerging market for Biochar has now formed with prices that vary widely depending on the quality and application in which it is used. An average value is 1200 € / Mg.bc, but it also reaches 8000 USD / Mg.bc for treated AgBC. On the national market, BC from forest biomass is offered at 1750 € / Mg.bc.

Due to the fact that AgBC has become a useful, salable product, local AgBC production systems are currently being promoted without heat recovery, which represents on average about 50% of the energy in the WB. Large amounts of PM material particles are also produced which pollute the environment. These systems are polluting and energy inefficient and their use must be restricted.

— Energy recovery of residual vegetable plant biomass

For the energetic and chemical capitalization, the residual vegetal agricultural biomass is introduced in fast, intermediate or slow pyrolysis processes from which results combustible gas (pyrogas), pyrolysis oil (bio–oil) and BioChar in proportion of 15–25%. The gas produced burns to produce thermal energy. From pyrolysis oil, cracking gives biofuels and other CHO components usable in the chemical industry.

For the production of electricity, gasification processes are used, which result gas.bm for powering the engines. The generation of electricity is done with an efficiency of 18% for steam or ORC cycles, 30% with internal combustion engines for gas and 60% for the mixed steam cycle type LESA. Currently, for small and medium powers, internal combustion engines for gas are mainly used.bm.

For the efficient production of heat and biochar, semi–gasification processes are used in which the fast pyrolysis is done with a reduced oxygen supply from the air and gas is produced.bm with a low tarr and Biochar. Technological concepts apply (Murad et al., 2016; Murad E., 2018; Murad E., 2020; Weber and Quickerb, 2018; www.bioenergyeurope.org)

- ≡ Combined Heat And Biochar production – CHAB – from biomass with pyrolisis or gasification is produced heat from gas burning and biochar;
- ≡ Combined Heat Power And Biochar production – CHPAB – from biomass with gasification is produced gas.bm utilise for power and heat production and biochar;
- ≡ Combined Heat Biochar And Power production – CHBAP – from biomass with gasification is produced gas.bm and biochar part of which used for power production in CHP.

— CHAB Systems

The paper presents analyzes CHAB systems equipped with Downdraft Stratified Inverted gasifiers, also called Inverted Downdraft (IDD) or TLUD – Top Lit Up Draft, abbreviated in paper with GSI.

GSI gasifier operate at atmospheric pressure in load regime with a specific hourly consumption of biomass in the range of 100 – 200 kg.bm/m^2h and with a variation of the thermal load 50 – 100% (Murad et al., 2016; Murad E., 2017; Murad E., 2018).

Gasifier can start automatically when and when needed, a mode of generation that requires very low energy storage capacities compared to wind and PV systems, with a high overall energy conversion efficiency. These systems are polycombustible, efficiently gasifying a wide variety of biomass with humidity <15%, chopped or pelletized – forestry, residual agriculture, energy crops, spontaneous flora – with conversion yields > 90% and overall energy efficiency > 75% compared to HHV.

On average, from 1 tone bmr.db can be obtained useful thermal energy of ≈ 2.5 MWht and 200 kg biochar with a minimum of 140 kg.carbon and an energy potential of at least 4.8 MWh (Murad et al., 2016; Murad E., 2017; Murad E., 2018).

In the GSI gasifiers gas.bm and biochar are produced with a conversion efficiency of > 93% and with an external carbon footprint of CFPex < 0. At an average production of 0.2 kg.bc / kg.bm.db in biochar remains on average 33% of the carbon of the gasified biomass Cbm.bc ≈ 0.33 Cbm. Gas.bm combustion produces very low CO and PM emissions. Usable thermal energy is produced with efficiency of heat exchangers maintained at ≥ 90%. At the output, useful thermal energy is obtained with an efficiency of at least 48% and biochar which has 32% of the input energy. The overall conversion rate relative to HHV is > 80% a perfectly good value.

With modern mass processing technologies for energy conversion the carbon footprint is CFPb ≤ 100 kgCO2 / Mg.bm.db (figure 1) and added to that of the CFPs aggregate results CFPf <130 kg.CO2 / Mg.bm.db = 52 kg.C /Mg.bm.db. For a minimum Cbc of 700 kg.C / Mg.bc and a coefficient of carbon retention in the soil for a long time Kef > 0.8 to obtain an external footprint CFPex <0 it is necessary that:

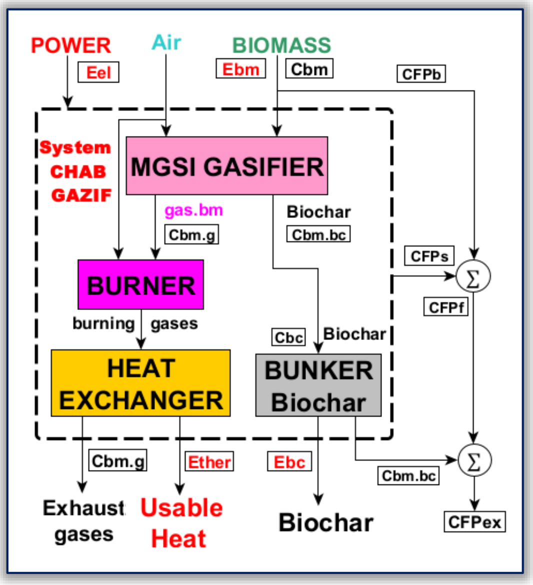

Figure 1. Block diagram for CHAB system with gasifier

$$CFPex = CFPf - BC \cdot Cbc \cdot Kef < 0 \tag{1}$$

and

$$BC > CFPf/(Cbc \cdot Kef) = 52/(700 \cdot 0{,}8) = 0{,}0928 \tag{2}$$

So it must be BC > 0.10. CHAB systems, depending on the thermal regime and the gasified biomass, produce BC in the range [0.12 – 0.22], ensuring a negative CFPex carbon footprint operation.

In optimal operation, energy and economic regime, BC ≈ 0.20 and it results that CFPex <52 – 0.2 · 700 · 0.8 = –60.0 kg.C / Mg.bm.db. It follows that CFPex < –220 kg.CO2 / Mg.bm.db and CFPex = – 90 kg.CO2 / MWhth, negative values difficult to match with other decarbonization processes.

Because the analyzed systems are of relatively low power 10 – 200 kWth, they can be placed directly next to the consumer, and produce energy when and how much is needed, thus achieving an economically and ecologically efficient decentralization that contributes to reducing endemic rural energy poverty.

The specific price of the aggregates is 120 – 180 € / kWth depending on the nominal power and the complexity of the system. CHAB gasification systems are safe to operate, simple and inexpensive, producing energy when and how much is needed with a negative carbon footprint.

— CHPAB Systems

The CHPAB systems currently produced use downdraft gas generators and internal combustion engines designed to run on cold and clean gas.bm. They produce electricity, heat and biochar, with a positive to zero or slightly negative CFPex footprint. (Figure 2)

Current commercial CHPAB systems produce 1 MWhe with a consumption of 1.2 Mg of dry wood biomass with an electrical energy efficiency of 13 –18%, as well as Biochar

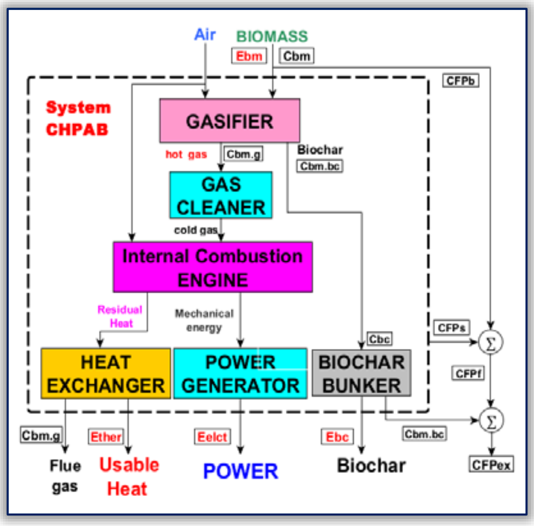

Figure 2. Block diagram for CHPAB system

which contains a maximum of 10% of the input carbon. The specific price of the aggregates is between 2000 – 3000 € / kWe.

Fuel gas, gas.bm, produced with CHAB systems burns very clean and can be used to produce electricity with external combustion engines. For low power, free piston or impeller turbine steam engines are usually used. For medium powers, Organic Rankin Cicle (OCR) or Stirlling systems are used.

— CHBAP Systems

Part of the biochar produced in CHAB systems can also be used to produce electricity with gas.bc and înternal combustion engines. (Figure 3). CHBAP systems produce decoupled thermal and electrical energy – when and as needed – with a cogeneration index of 7.5%, sufficient for many agricultural processes: food drying, greenhouses, heated solariums, primary processing sections, farm premises, as well as for the community in schools, medical offices, town halls, etc.

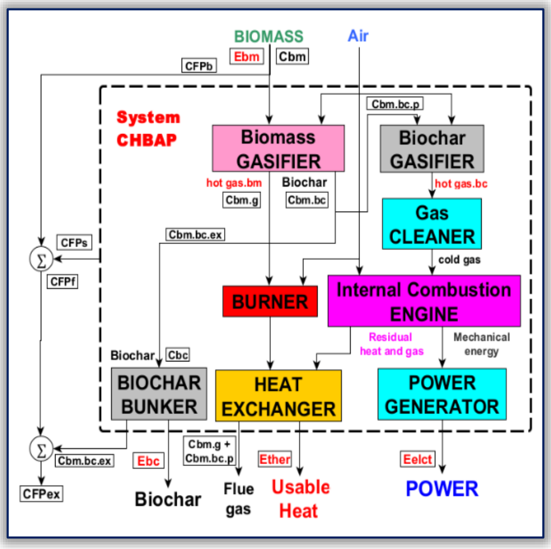

Figure 3. Block diagram for CHBAP system

Energy safety and independence are achieved with minimal biomass consumption and very low storage capacities in hot water and accumulator batteries. From one ton of dried vine strings is produced 3.3 MWhth, 250 kWhe and 20 kg. biochar with a negative footprint of – 48 kg.CO_2.

The specific value of the investment varies from 800 to 1200 € / kWe depending on the power and the required structure. For a higher energy consumption you can put in parallel as many systems as necessary.

3. RESULTS

In table 3 is presented mass and energetic analysis of the use of RABM in RO with CHAB systems.

It is estimated that 19 Tg. of agripellets with an energy potential of 82 TWh can be produced, which with CHAB process systems can produce 40 MWhth and 3.8 Tg. of biochar, with an energy efficiency of 80% higher than the EU limit of 75% of HHV. The energy produced would be 7 times the annual energy consumption in agriculture estimated at 6 TWh / year.

The agripellets can be stored safety for long periods with an energy density of 2.7 MWh/m^3 which ensures the production of energy when and how much is needed with very small storage capacities compared to wind and photovoltaic systems that have a positive carbon footprint. The energy produced from RABM is cheaper and with a negative carbon footprint

The heat produced with CHAB systems with negative CFPex and can be used for heating residential and living spaces in urban and rural areas, for drying agricultural products and heating greenhouses.

Heating in cold seazon represents about 40% of total annual RO energy consumption. If allocated 40% from the annual RABM potential is available for space heating 9 TWh/month, with a reduction of CO_2 emissions by 15% and remains to be used monthly another 4.5 TWh/month for other applications.

If 25% of the estimated RABM energy potential is used for drying vegetables and fruits, with a drying efficiency of 40%, about 13.6 Tg. of water can be extracted annually and for a maximum crops humidity of 85% can be dried annually 15.6 Tg of vegetables and fruit.

For the sequestration of carbon from biochar in the soil, technologies and machines for storage and incorporation processing must be designed and developed, the costs will be recovered by increasing the agricultural production and by green certificates.

In table 4 is presented an estimate of the economic effects of energy and biochar production from annual RO RABM by using gasification systems with CHAB concept.

For an average price of 110 € / Mg. for the annual production of agripellets would be worth 2 billion EURO with an annual contribution to the budget through VAT of 395 million EURO.

The biochar incorporated in the soil benefits from green certificates 50 € / Mg.CO_2 and a minimum capitalization price for EU of 680 € / Mg.bc, which leads to an annual income of 1.8 Billion € or 94 € / Mg.pel. The economic analysis indicates that the capitalization of RABM by gasification with systems with CHAB concept is also with positive economic efficiency, which can lead to the increase of agricultural Incomes.

In table 5 is presented an analysis of the ecological effects of energy production and biochar from RABM by using gasification systems with CHAB concept. It can be seen that the energy recovery of the annual RABM is done with a

CFPf emission = +2.2 TgCO2 / year and by sequestering in the soil the carbon from the biochar produced, an external footprint of −7.0 $TgCO_2$ can be obtained. This represents about 6% of the annual emissions from RO and 38% of emissions from RO agriculture. It is found that it can make an essential contribution to reducing GHG emissions to meet GNDE requirements, with energy production and positive economic efficiency.

Table 3. RABM energy recovery (SoftEROL2020 ®)

Feature	M.U.	Value
Annually dry BMR mass collected	Tg.bmr.db/year	21.000
Energy potential at BMR collection	TWh/year	100.000
Specific energy for agripellets production	kWh/Mg.bmr.db	300.000
Utilization coefficient for pelleting	%	90.00
Agripelete mass produced annually	Tg.pel.db/year	18.900
Annually Usable net energy	TWh/year	90.000
Average biochar production with CHAB	g.bc/g.bmr.db	0.200
Biochar mass produced annually	Tg.bc/year	3.780
Carbon content in biochar (minimum)	g.Cbc/g.bc	0.700
Annually Carbon mass in biochar	Tg.Cbc/year	2.646
Biochar Higher Heat Value (average)	Wh/g.bc	7.000
Annualy biochar energy potential	TWh/year	26.460
Energy efficiency heat production	%	48.00
Useful thermal energy produced with CHAB	TWh/year	43.200
Biochar energy production efficiency	%	32.06
Overall efficiency of CHAB use	%	80.06
AGR + SILV energy consumption 2018	ktep	520
AGR + SILV in 2018 year energy consumption	TWh	6.048
Energy consumption AGR2018 / potential agripellets	%	14

4. CONCLUSIONS

In Romania, at a collection level of only 67% in 2018, 21 Tg. could be obtained dry residual agricultural agricultural biomass with an energy potential of 100 TWh and a content of 5.5 Tg. carbon, usable for reducing fossil fuel consumption and for decarbonizing agricultural activities. These values are also acceptable for 2021.

CHAB and CHBAP processes produce economically and ecologically energy from RABM – as well as when needed – and biochar that meets european and international quality requirements. Biochar can be used as an agricultural amendment with the name of AgriBiochar, being the most economical and ecological procedure for storing carbon that ensures an increase in agricultural production by at least 13%, which over time ensures great economic efficiency.

Table 4. Economic recovery of RABM (SoftEROL2020 ®)

Feature	M.U.	Value
Annual mass pellets produced	Tg.pel.db/year	18.900
Average cost agripellets	€/Mg.pel	110.00
Value of agripellets produced	M€/year	2079.00
Annual TVA	M€/year	395.01
Agripellets annual energetic potential	TWh/year	90.000
Average production of best biochar	g.bc/g.bmr.db	0.200
Annual produced mass biochar	Tg.bc/year	3.780
Carbon content (average)	kg.Cbc/kg.bc	0.700
Carbon sechestrabil in BC	Tg.Cbc/year	2.646
CO2 mass annual sequestrable	Tg.CO2/year	9.702
Value of green certificat	M€/Tg.CO2	50.000
Sale price for Agribiochar	M€/Tg.agbc	680.00
Thetmal energy produced	TWht/year	43.200
Heat cost for direct pellets burning	M€/TWhth	45.00
Total specific costs for CHAB use	€/Mg.pel.db	170.00
Total annual production costs	M€/year	3213.00
Coming from green certificates	M€/year	485.10
Biochar income from capitalization	M€/year	2570.40
Annual costs for heating	M€/year	157.50
Coming fro heating	M€/year	1944.00
Gross annual income	M€/year	1786.50
Specific income	€/Mg.bmr	94.52

Table 5. Analysis of the reduction of total and pure CO2 emissions (SoftEROL2020 ®)

Feature	M.U.	Value
CO2pur share of total emission–EU	%	81.0
Annual CO2ec RO 2018 emission	TgCO2/an	114,800
Annual emission CO2pur RO 2018	TgCO2pur/an	92,988
Annual CO2ec emission AGR RO 2018	TgCO2/an	18,320
Annual CO2pur emission AGR RO 2018	TgCO2pur/an	14,839
Annual estimated production of dry agripellets	Tg.pel.db/an	18,000
CO2 footprint for pellet production	Mg.CO2/Mg.pel.db	0,100
CO2 footprint manufacturing and system use	Mg.CO2/Mg.pel.db	0,0250
CO2 footprint specific for system operation	Mg.CO2/Mg.pel.db	0,125
Annual operating CO2 footprint	Tg.CO2/an	2,250
Annual operating carbon footprint	Tg.C/an	0,614
Medium production of Biochar	Mg.bc/Mg.pel.db	0,200
Biochar mass produced annually	Tg.bc/an	3,600
Minimum carbon content in biochar	g.C/g.bc	0,700
Biochar carbon masse produced annually	Tg.Cbc/an	2,520
Carbon masse sequestrable annually	Tg.C/an	–1,906
CO2 masse sequestrable annually	TgCO2pur/an	–6,990
Reduction from RO 2018 emission	%	–6,09
Reduction from AgrRO 2018 emission	%	–38,16S

Annually, in Romania, 19 Tg. of agripellets can be produced, from which with CHAB systems it is possible to obtain 43 TWh of thermal energy and 3.7 Tg. of Biochar with an annual income of 1.7 T € / year or 94 € / Mg.bmr.db , which indicates an investment opportunity to increase agricultural incomes and reduce energy poverty.

The biochar produced annually would contain at least 2.5 Tg. carbon that introduced into agricultural soil over a long period sequestrates 1.9 Tg.C / year is 7 Tg.CO2 / year which would reduce by 38% the GHG emissions produced by agriculture and can ensure an increase of at least 13% of agricultural production on the treated lands.

Strips of maize stalks and stalks, sunflower stalks and vegetable stalks, which represent 80% of the annual energy potential, have a high content of easily fusible ash and alkalis and are not suitable for direct combustion. Through CHAB and CHBAP processes, their energy potential can be optimally exploited, heat, electricity and biochar are produced with a negative or zero carbon footprint and with very low PM emissions.

CHAB systems produce thermal energy and biochar – when and as needed – with an energy efficiency of at least 80% and a negative CFPex carbon footprint. On average, 1 tone bmr.db can be obtained ≈ 2.5 MWhth useful thermal energy, 200 kg biochar with minimum of 140 kg carbon and an energy potential of 4.8 MWh. The final carbon footprint is minim –400 kg.CO2/Tg.bmr.db

CHBAP systems decouple thermal and electrical energy – when and as needed – with a cogeneration index of 7.5% and a sub–zero CFPex carbon footprint, ensuring energy safety and independence with minimal biomass consumption and very low capacity storage in hot water and accumulator batteries. From 1Mg. dry chopped vines can be obtained 3 MWhth, 150 kWhe and 20 kg.bc.

CHAB and CHBAP systems that produce energy and AgriBiochar can be fully produced in Romania, are simple, safe and cheap, is automatically driven with expert systems and easy to connect in Smart Grids that include other energy sources, contributing to decentralization, to an efficient use of the energy resource and as an energy support in crisis situations.

The CHAB and CHBAP systems are easy to use by operators with average training, contribute to the increase of the employment level, in the rural environment, contributing to the increase of incomes and living standard.

By energy recovery of residual agricultural plant biomass, Energy and BioChar are produced without residues and with zero or negative CO2 emissions, in the concept of Circular Economy, jobs are created, energy security in agricultural farms is increased and the objectives of PNRR to reduce GHG emissions.

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