CIRCULAR ECONOMY ATTRIBUTES TO RENEWABLE ENERGY

May 31, Brasov, Romania

Erol Murad

Universitatea POLITEHNICA Bucuresti

For a circular economy - Heat, Power and Biochar from agricultural and forestry residual biomass

Spre o economie circulară – Căldură, Electricitate și Biochar din biomasă reziduală agricolă și forestieră

For a circular economy

The European Commission adopted in 2015 an action plan to accelerate the transition to the circular economy to "**close the circle**„ in the life cycle of products - from production and consumption, to waste management and the secondary raw materials market, to stimulate global competitiveness, to promote sustainable economic growth and to create new jobs.

There are five priority sectors in which the transition must be accelerated: plastics, food waste, critical raw materials, construction and demolition, ***biomass and biomaterials***. The red thread in all actions is the need to create a solid base, a fertile ground for investment and innovation.

For sustainable economic development, it is necessary to **increase ENERGY independence and security** by using all local and regional energy resources, of which **BIOMASS** is central.

For a ***Circular Economy*** *it is* presents a recent alternative to the use of **BIOMASS** for **HEAT, POWER** and **BIOCHAR** production with a **negative carbon footprint** and ***without any residues*** from new concepts:

CHAB (**C**ombined **H**eat **A**nd **B**iochar)

and

CHPAB (**C**ombined **H**eat **P**ower **A**nd **B**iochar)

Why **BIOMASS** for **energy**?

There is with abundance

It's cheap (yet !)

It is a renewable energy source

It produces clean energy

It is a quality **BIOCHAR** source

WHEN AND WHAT IS NECESSARY!

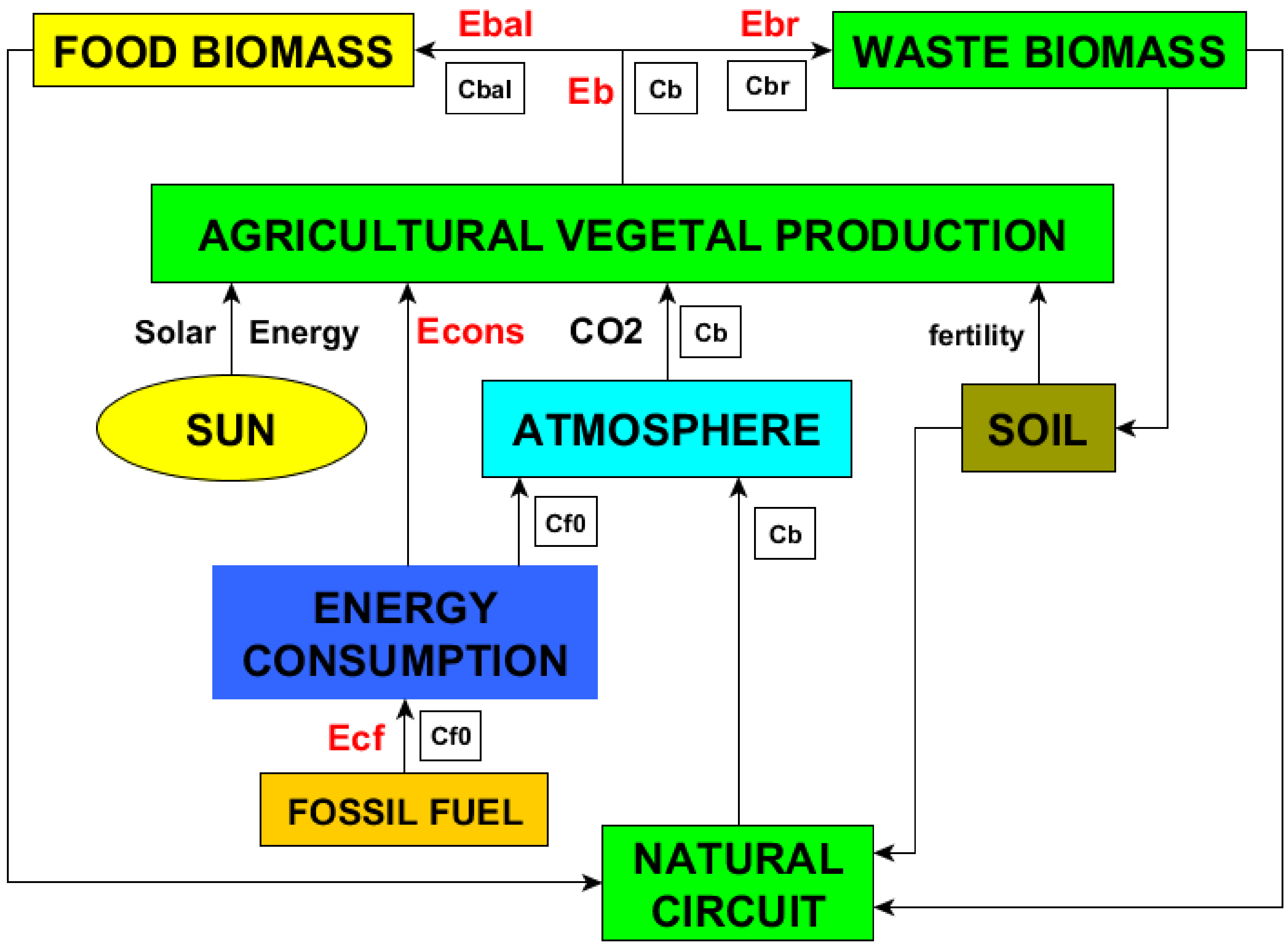
ROMANIA has an **agricultural and forestry residual biomass** potential of **31 Mt.bmr/year**, and by increasing the vegetable production at the EU average it can add another **40 Mt.bmr/year**, of which only **24 Mt.bmr** would be needed to ensure the heating needs of the population and electricity for local consumers.

For an average biomass **LHV** **3 MWh/t.bmr**, now the national level biomass energy resource is about **9 TWh/year** and be estimated to **21 TWh/year**.

Table 2: Realistic potential (RP) of agricultural crop residues in the EU

Crop	*Yield increase in RP through best practice strategies*	*High yielding (i.a. France) Mt/year*	*Medium yielding (i.a. Poland) Mt/year*	**ROMANIA** *Low yielding (i.a. Romania) Mt/year*	*Total Realistic potential (Mt/year)*
Wheat	4-11%	5.095	6.891	19.298	31.285
Barley	7-13%	2.379	4.755	4.856	11.990
Maize	9-16%	3.096	5.020	7.339	15.455
Rye	7-13%	0.130	0.880	0.924	1.935
Oats	7-13%	0.388	0.568	0.504	1.460
Sunflower	9-16%	0.118	0.802	0.832	1.752
Rape	9-16%	0.614	2.113	5.933	8.661
Sugar beet	14-21%	0.047	0.321	0.333	0.701
Wine	13-17%	0.031	0.655	0.558	1.244
Total		11.9	22.0	40.6	74.5

Residual agricultural biomass - main renevable source for energy



In atmosphere, through natural carbon circuit, **carbon footprint** is **ZERO**!

Energetic efficiency of agricultural crops

EFEN = (Ebal+Ebr)/Econs = EFENp + EFENs > 1

Crop	Energy produced			Energy consumed	Energetic efficiency		
	Etotal	Ebal	Ebr	Econs	EFEN	EFENp	EFENs
	kWh/ha	kWh/ha	kWh/ha	kWh/ha			
Corn	91029	41054	49975	5163	17,63	7,95	9,68
Winter wheat	41017	16773	24244	5764	7,12	2,91	4,21
Beans	21227	10585	10642	3254	6,52	3,25	3,27
Sunflowers	19807	4970	14837	4982	3,98	1,00	2,98
Soy	29517	18550	10967	4643	6,36	3,99	2,36
Plum	23981	12775	11206	12833	1,87	1,00	0,87
Vineyard	17547	8381	9167	16028	1,09	0,52	0,57
Apple	22372	14467	7906	17383	1,29	0,83	0,45

Residual agricultural biomass is produced with an energy efficiency of **0.6-10 kWh.bmr/kWh.cons**, an average of **6 kWh.bmr/kWh.cons.**

The current **residual biomass** potential can cover the energy consumption of vegetal agriculture production for an energy yield conversion > 20%.

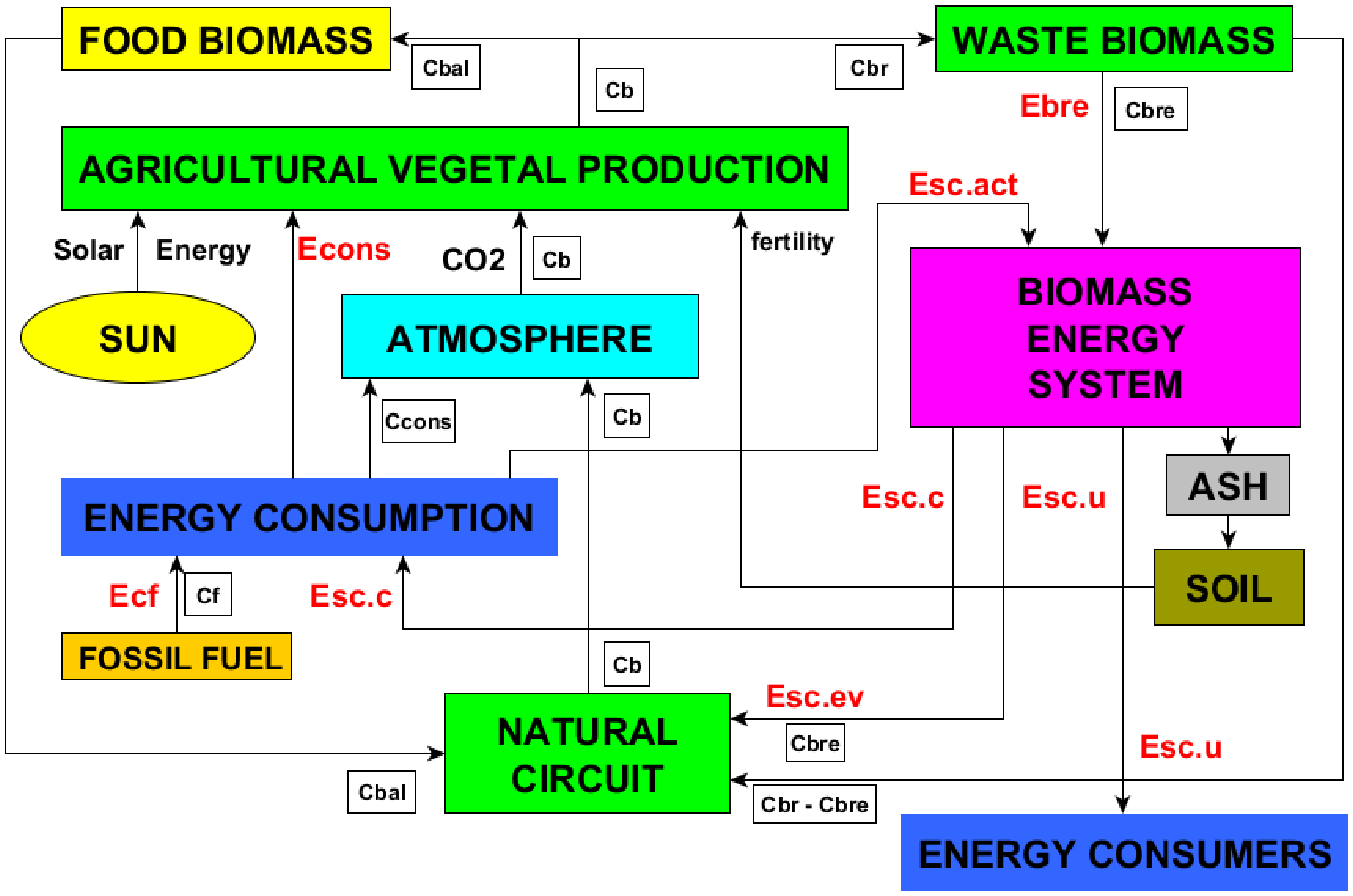
Cogeneration with **residual biomass** have an electric efficiency: - **25%** without biochar production,
- **15%** for a 15% biochar production.

It follows that even a partial recovery of **residual biomass** can cover much of the energy consumed in vegetal and animal production and, as well as in the processing of agricultural production with the negative carbon footprint.

The energy conversion of **biomass** is done with processes:

- **Burning**, which has high yield but high PM
- **Gasification**, produces gas that burns smoke-free
- **Pyrolysis**, produces biochar, bio-oil and gas

Production of ENERGY by biomass combustion processes



Aplications
fully automated
ECOHORNET (RO)

Thermal agent:
hot water, air or oil

Global energetic yield
> 75%

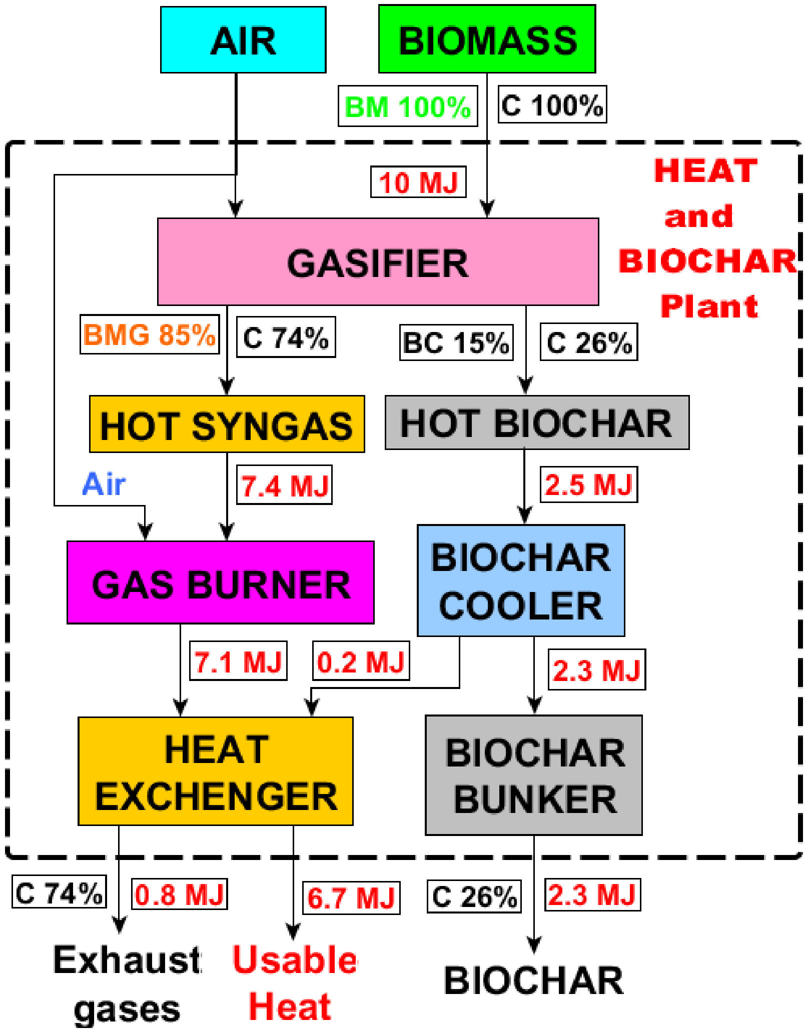
More PM and NO3 ⇒
fine filters and repeated cleaning

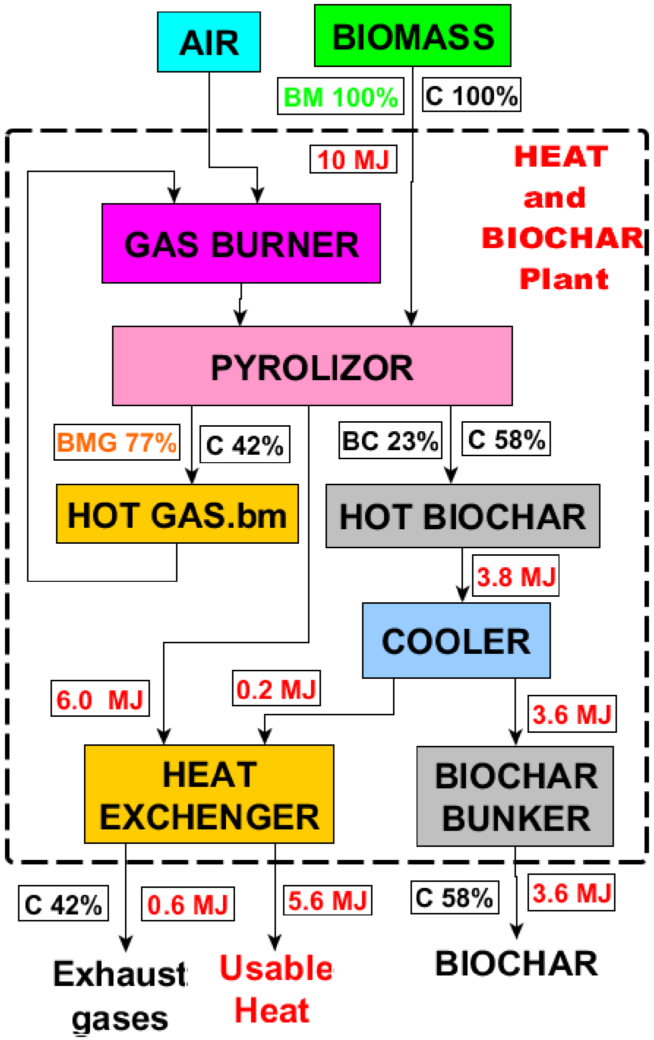
Carbon footprint
slightly above zero

As an alternative to the current ways of producing thermal energy through biomass combustion processes, the use of CHAB (Combined Heat And Biochar production) combines synergistically the production of HEAT and **BIOCHAR** (**BCH**) with very low PM and CO emissions, such as and a negative final atmospheric CO_2 balance and negative carbon footprint.

By means of anoxic **pyrolysis** or controlled **gasification** processes from **biomass** is obtained combustible gas (gas.bm) and a sterile active carbon body with a high gas and liquid absorption capacity, which is called **BIOCHAR**.

Energy production from biomass in CHAB concept





Biochar (BCH)

BCH is a sterile plant carbon produced from anoxic pyrolysis of biomass or from a substoichiometric gasification process. It is obtained in a proportion of 12 - 25% depending on biomass and thermal regime.

BCH has 75-92% carbon and is characterized by a very high porosity and adsorption capacity. It can be used as an agricultural amendment to increase soil fertility, as a animal feed additive, and as a filtering material for air, gas and water.

Why BIOCHAR?

As agricultural amendment:

Environmentally and economically sequester atmospheric C

Remember nutrients by increasing CEC

A substrate for the growth of microorganisms

Increase soil pH - acidity reduce

Retain water

Simple to incorporated

As filter material

Drinking Water

For emission ammonia, nitrogen oxides, sulfur dioxide

Retains nitrogen in compost

The part used from residual biomass for ZERO carbon footprint

$$Kbe = \frac{CFPf}{CFPbm} \cdot \frac{1}{Kbch \cdot EFENs}$$

Where: **Kbe** is – part of waste biomass used for energy
Kbch is – yield of biochar production
CFPf is – carbon footprint fosile fuels
CFPbm is – carbon footprint waste biomass

For gasification results $\mathbf{Kbe_g} \geq 0.44$, and for pyrolysis $\mathbf{Kbe_p} \geq 0.23$.
If using gasification, more energy is available for external applications

For **Kbe** = 0.67 : with gasification $\mathbf{CFPatm_g}$ = - 0.124,
with pyrolysis $\mathbf{CFPatm_p}$ = - 0.814.

AgriBiochar (AgriBCH)

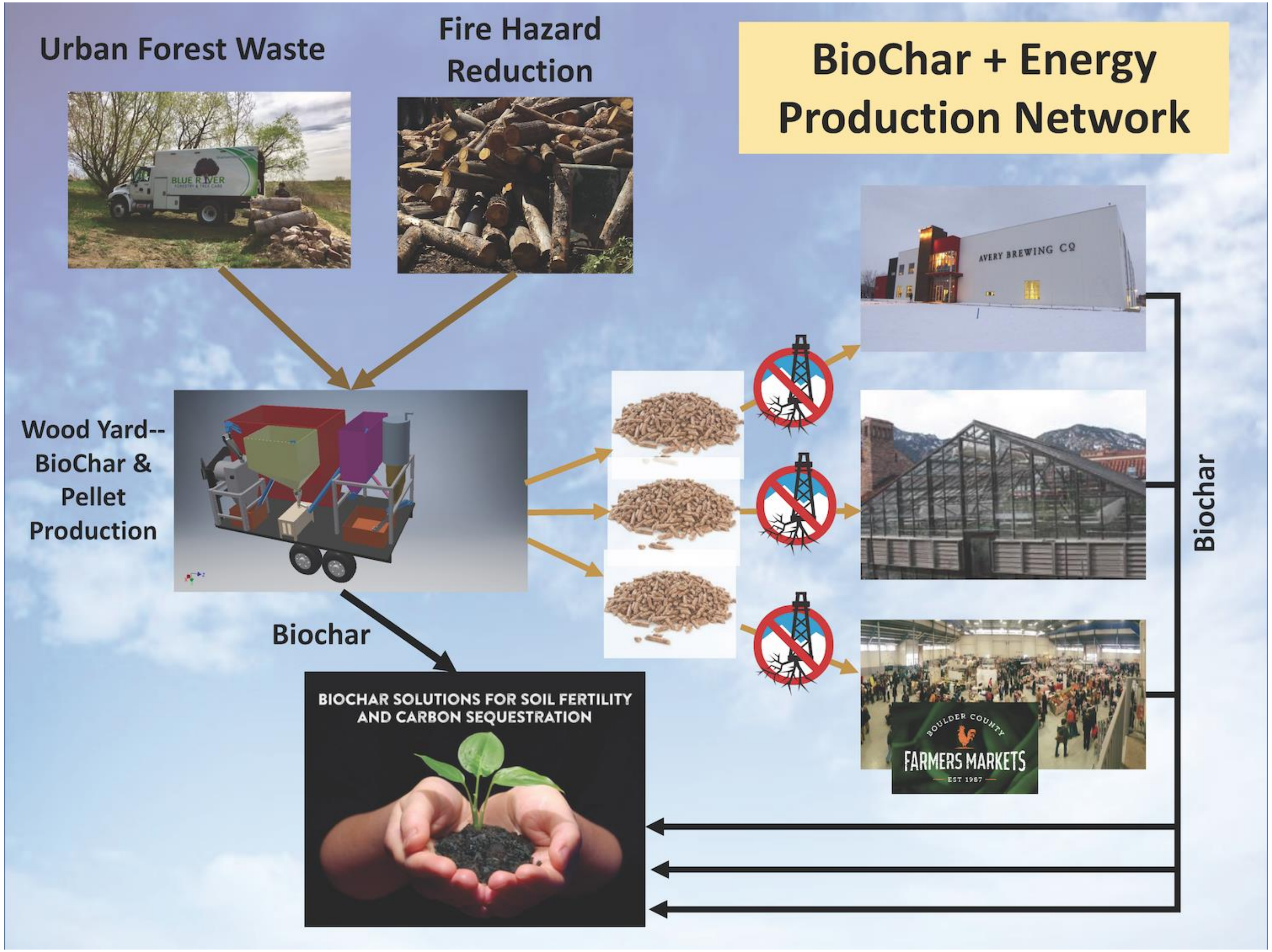
BCH with very low volatile and heavy metals, named AgriBiochar, embedded in the soil is the most economical and environmentally friendly sequestration method of carbon for long periods of time. From the biomass carbon content of 30-50% is immobilized in the soil.

Is known for moderating soil acidity, increasing water and nutrient retention, benefitting soil microbes, increasing plant yields and so much more.

Most of the studies performed have shown beneficial effects of the use of ***AgriBIOCHAR*** in agricultural production; in **58%** of cases the agricultural yield increased and in **37%** of the cases, no differences were found.

From a recent **statistical meta-analysis** of global results, a significant positive effect has emerged: **a 12% increase in agricultural output**. The authors used data from several extensive and high-quality studies focusing on the overall impacts of **AgriBCH** use, based on important factors such as soil pH, soil type, fertilizer dose, feedstock for BCH, application rate and crop species.

Since **1984** **Japan** and in **2013** **Switzerland** and **Sweden** have officially approved the use of ***AgriBiochar*** as an amendment to agriculture. Approval is based on stringent, scientifically verified requirements regarding the durability of biochar production, **the quality of the biochar** and the protection of users when applied.



Urban Forest Waste
BLUE RIVER
Fire Hazard Reduction
BioChar + Energy Production Network
AVERY BREWING CO
Wood Yard-- BioChar & Pellet Production
Biochar
BIOCHAR SOLUTIONS FOR SOIL FERTILITY AND CARBON SEQUESTRATION
BOULDER COUNTY
FARMERS MARKETS
EST 1987
Biochar

Experiment for biochar efficiency in vegetable growing.

Work for the master dissertation thesis **Eng. Dima Alexandra** at Adunatii Copaceni in April 2017.
The biochair is produced at **PROMECO-SD** Bucharest by masteand **Eng. Alexe Mihai** from pellets produced **by Eco Pellet Energy SRL** - Campina

0 5 10 15 20 Dose%

Radish crop at 2 weeks

20 15 10 5 0 Dose%

Radish crop at 6 weeks

Optimal concentration 10%

Experiment for biochar efficiency in vegetable growing

Work for the master dissertation thesis **Eng. Dima Alexandra** at Adunatii Copaceni in April 2017.
The biochair is produced at **PROMECO-SD** Bucharest by masteand **Eng. Alexe Mihai** from pellets produced **by Eco Pellet Energy SRL** - Campina

0 5 10 15 20 Dose%

Tomato crop at 2 weeks

0 5 10 15 20 Dose%

Tomato crop at 6 weeks

Optimal concentration 15%

Experiment for biochar efficiency in vegetable growing

Work for the master dissertation thesis **Eng. Dima Alexandra** at Adunatii Copaceni in April 2017.
The biochair is produced at **PROMECO-SD** Bucharest by masteand **Eng. Alexe Mihai** from pellets produced **by Eco Pellet Energy SRL** - Campina

0 5 10 15 20 Dose%

Spinach
Culture
2 weeks

0 5 10 15 20 Dose%

Spinach
Culture
6 weeks

The optimal concentration is 20%
but with inconclusive differences

Cost of biochar production ($/t.bc)

Tip Biomasă	Fără CHAB	Cu CHAB
Pelete din lemn	1250	950
Așchii de lemn	700	400
Pelete din iarbă energetică	850	580
Pelete din așternut grajd	400	350
Pelete din așternut broileri	180	80

Biochar price EURO/t.bc (2015)

Tara	Media	Minim	Maxim	Observatii
Australia	2800	2000	3600	*liber*
Austria	4850	4850	4850	*Impus (2013)*
Canada	3270	400	1000	*liber*
Elveţia	1000	1000	1000	*impus*
Germania	800	500	1160	*liber*
Spania	620	620	620	*Impus (2013)*
Anglia	2200	880	6000	*liber*
USA	1573	574	6300	*liber*

From ***Eolian*** and ***PV*** **renewable energy** sources **carbon footprint is near to zero**, ***when it is windy and sunny.***

To produce energy ***when and when necessary*** *for autonomous and isolated locations* have been developed cogeneration plants named **CHP**:

CHP = Combined **H**eat and **P**ower production**.**

They produce useful **HEAT** and **POWER** from **fossil fuel** consumption with a **large carbon foot print.**

For CHP with BIOMASS **carbon footprint is negative.**

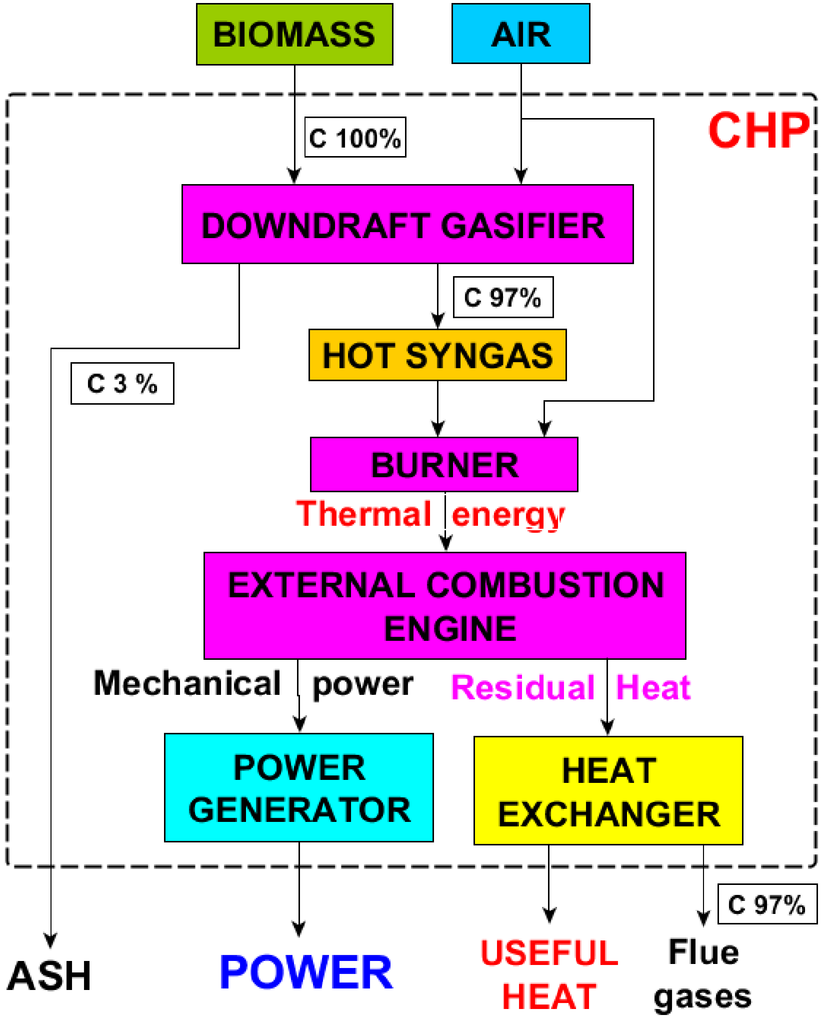
For homes and other small isolated users, micro-cogeneration plants with power ranging from 1 to 100 kWe have been developed that produce electricity and heat at competitive costs, with a good fiability, durability and easy maintenance.

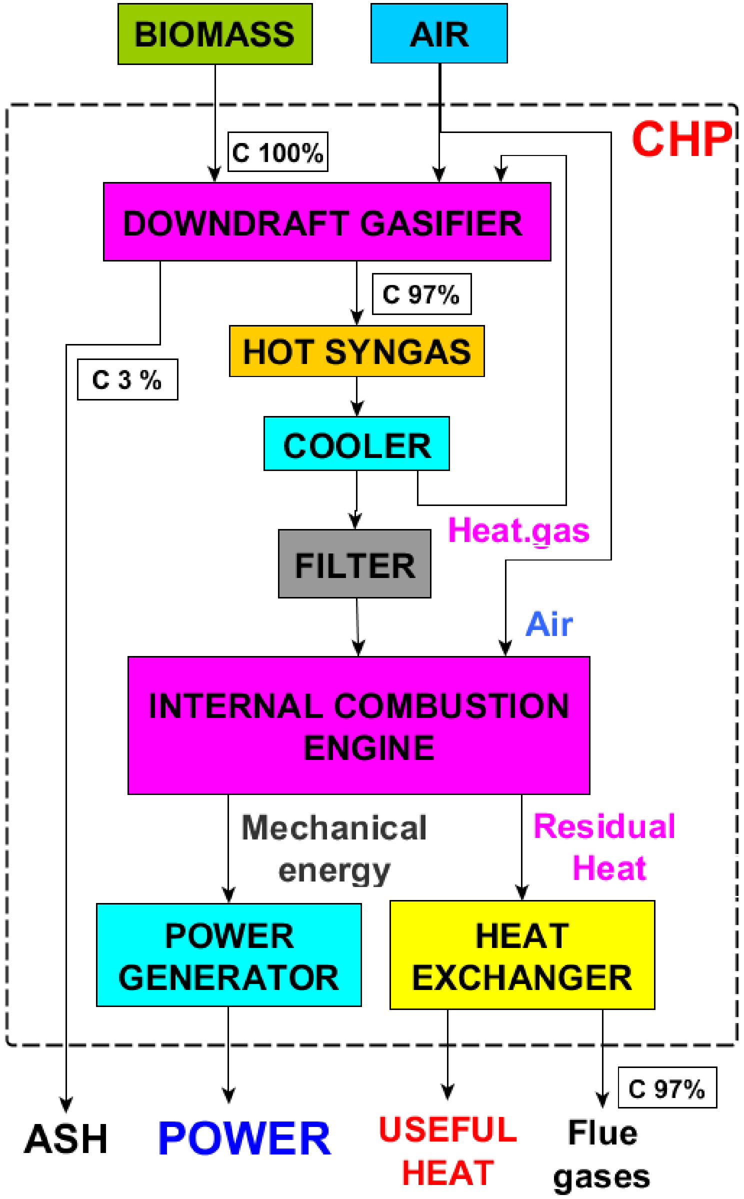
Micro-cogeneration systems, easy to integrate into a small energy intelligent network type *Smart Grid* that manages all available energy sources, renewable or classical, which increases energy efficiency and reduces the cost of use

Current is produced and sold micro-cogeneration plants at specific prices of 2000 - 6000 €/kWe depending on the plant structure and the fuel used.

For a *Circular Economy* the paper presents a recent alternative to the use of BIOMASS in micro-cogeneration plants for HEAT, POWER and BIOCHAR production with negative carbon foot print in CHAB and CHPAB (**C**ombined **H**eat **P**ower **A**nd **B**iochar) **concepts.**

Micro-CHP
with
downdraft gasifier





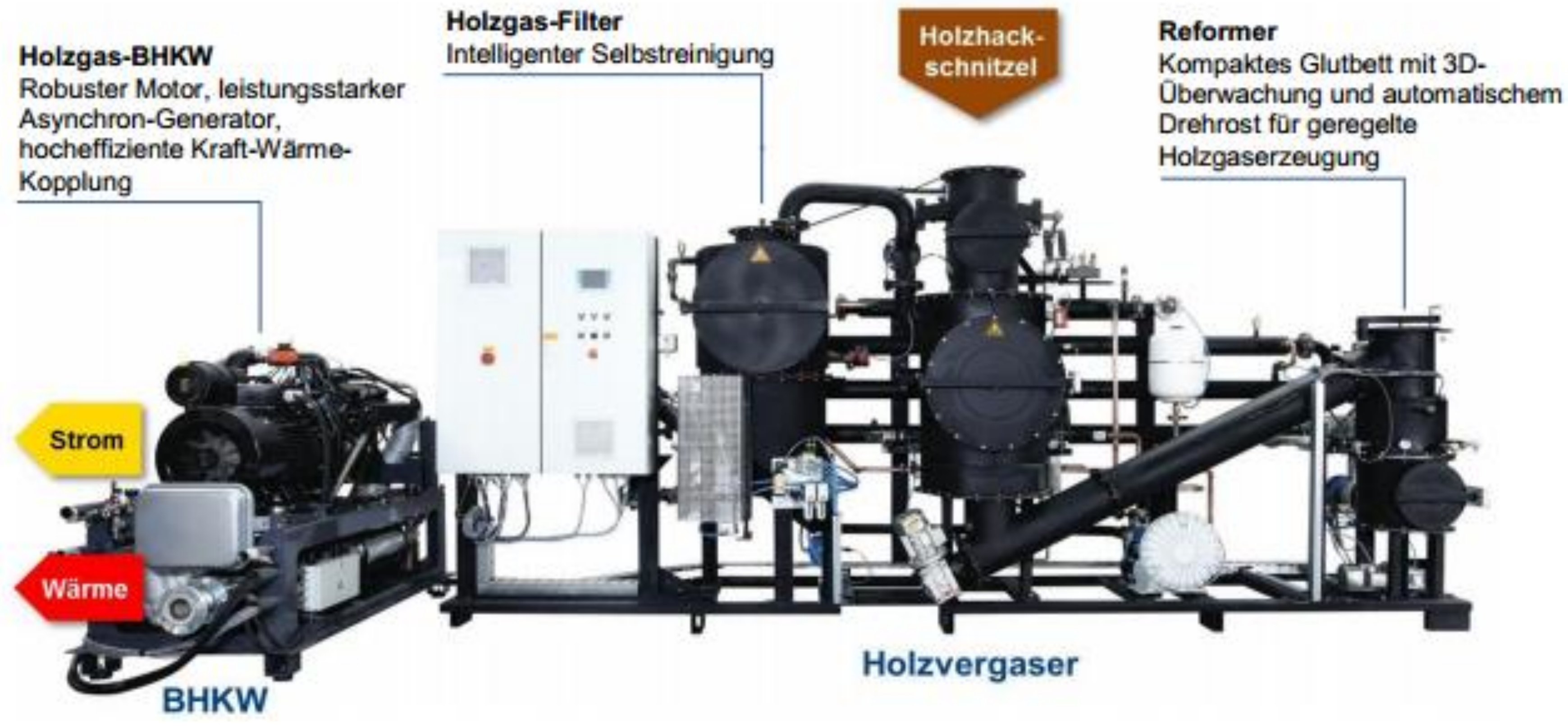
Spanner Re² Holz-Kraft

Down-draft gasifier

for biomass chips and

internal combustion engine

micro-CHP with biomass downdraft gasifier



If the combustible gas produced in **CHAB** (named ***gas.bm***) is used to produce **POWER** in **CHP** plant then is being developed another concept:

CHPAB = **C**ombined **H**eat, **P**ower and **B**iochar production.

Cogeneration plants use thermal engines to drive generators.

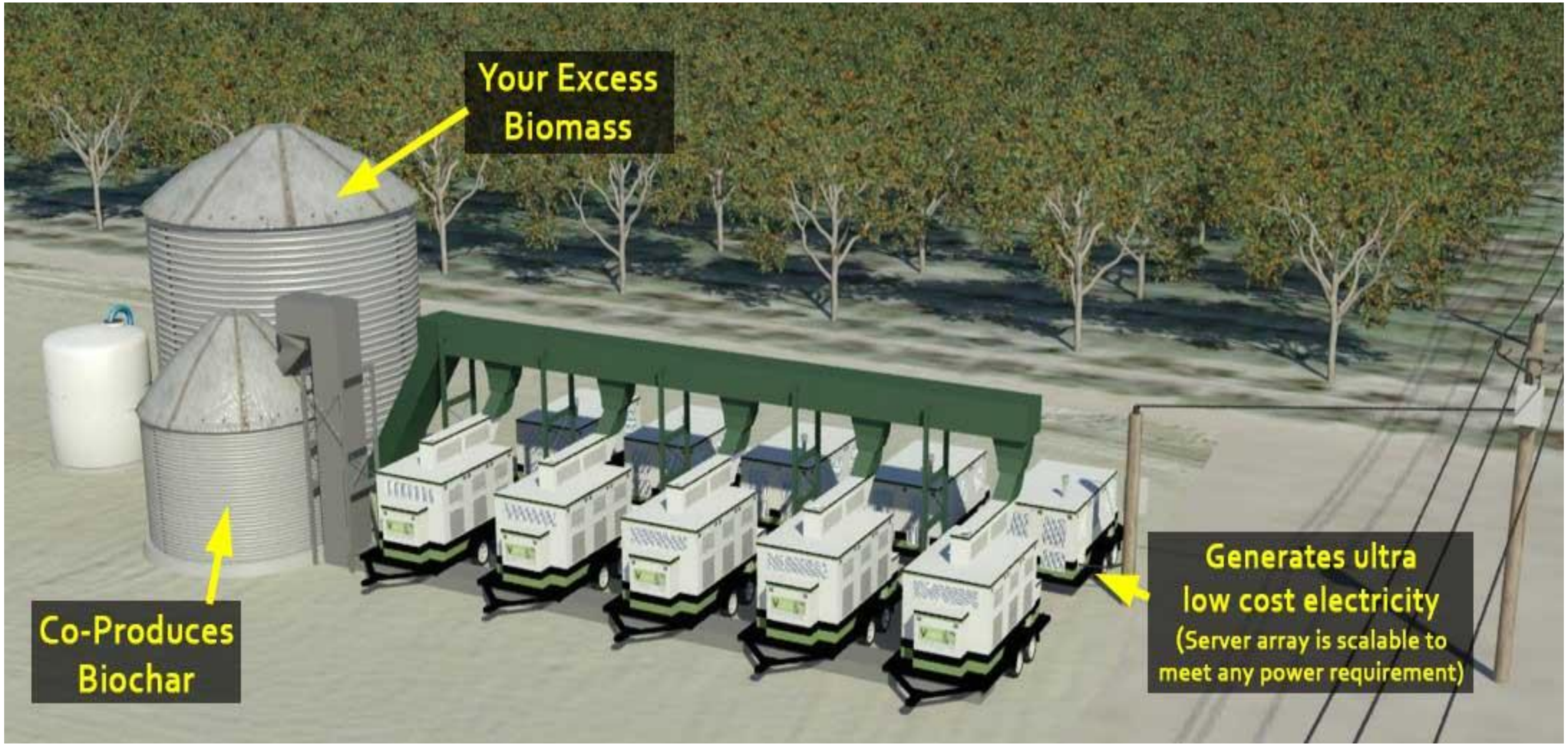
External combustion engines:

- Steam piston engine,
- Steam turbine engine,
- Stirling.

Internal combustion engines:

- gas engine startup with gasoline,
- gas engine startup with LPG,
- gas engine startup directly with ***gas.bm***

V-GRID plant with a **CHPAB** concept producing **500 kWe** and **biochar** from residual vegetable crops in a farm



PP20 energy device
from
All Power Labs
with CHPAB concept

Patent USA - US 2017130131

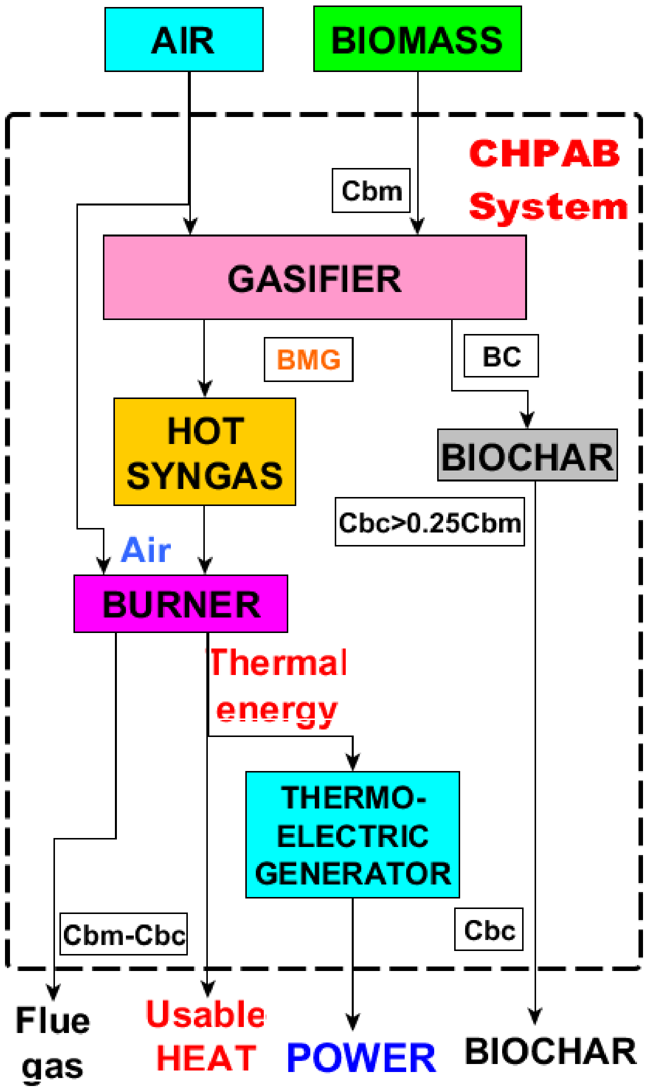
"Gasifier with controlled biochar removal mechanism"

11 May. 2017

1 tone of dry biomass produce
1MWh of **electricity**
50 kg of **biochar**.

Micro-CHP

BIOLITE Camp Stove with IDD gasifier and Thermo-Electric Generator



CHPAB concept for Cogeneration plant with I. C. E. and Energy recovery

BIOCHAR = 15 %

ELECTRICAL efficiency = 11,5%

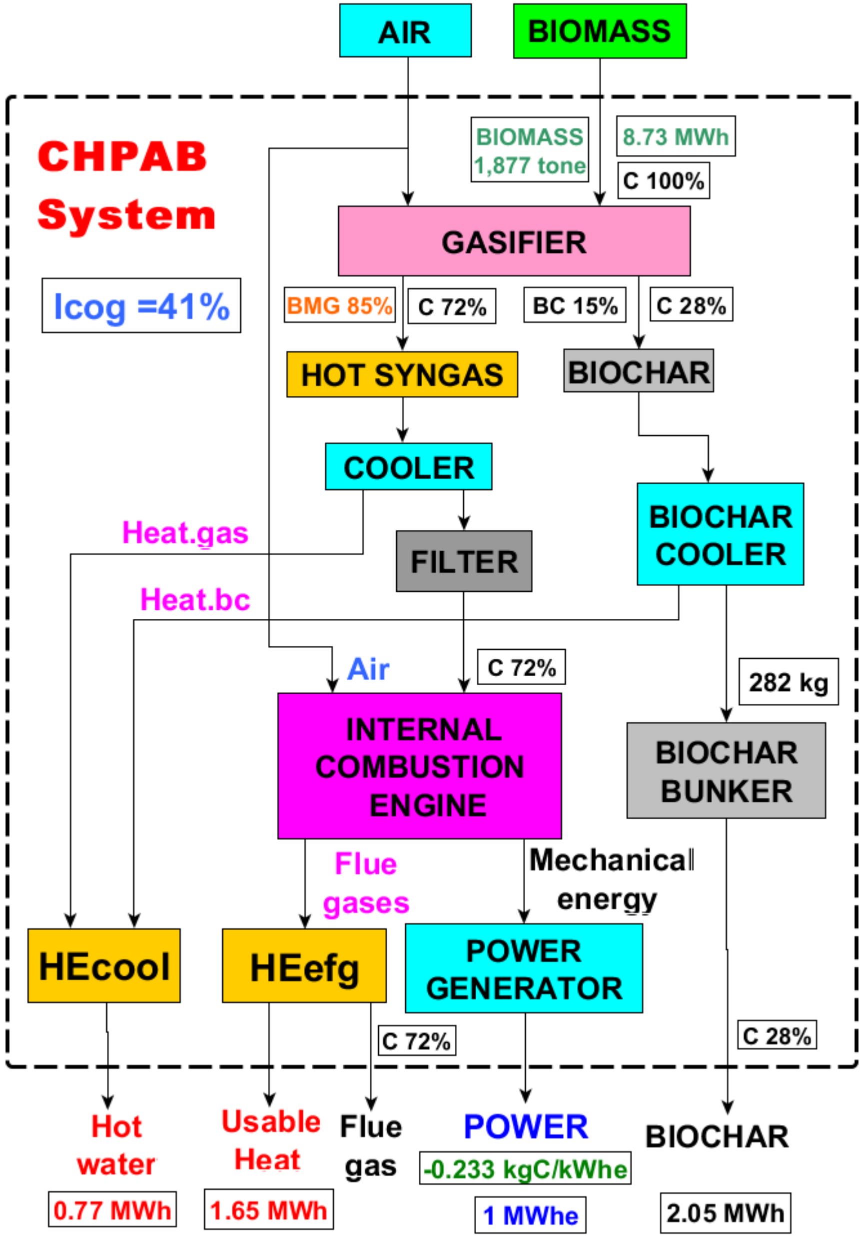
TERMAL efficiency = 27,8%

CHP efficiency = 39,3%

BIOCHAR efficiency = 23,5%

CHPAB efficiency = 62,8%

Cogeneration Indice = 0,413



CONCLUSIONS

1. The European Commission adopted in 2015 an action plan to accelerate the transition to the ***circular economy*** to ”**close the circle**” in the life cycle of products - from production and consumption, to waste management and the secondary raw materials market.

For sustainable economic development, it is **necessary to increase energy independence and security** by using all local and regional energy resources, of which ***biomass*** is central.

CONCLUSIONS

2. **ROMANIA** has an **agricultural and forestry residual biomass** potential of **31 Mt.bmr/year**, and by increasing the vegetable production at the **EU** average it can add another **40 Mt.bmr/year**, of which only **24 Mt.bmr** would be needed to ensure the heating needs of the population and electricity for local consumers.

In order to capitalize on this potential, we need to use as much as possible the **agricultural and forestry residual biomass** for a ***circular economy*** to produce ***HEAT***, ***POWER*** and ***AgriBIOCHAR*** for increase the productive potential of the soil.

CONCLUSIONS

3. From ***residual biomass*** with **CHAB** concept is produced **HEAT** with 65% energy yield and **AgriBIOCHAR** with a 25% energy yield, and a total energy conversion yield is **90%,** ***without any residues*** and a **negative carbon footprint**.

AgriBIOCHAR incorporated in agricultural land, contribute to their productive potential, contribute to sustainable development and are financially accessible for agricultural farms and isolated communities.

CONCLUSIONS

4. Micro-cogeneration plants with ***residual biomass*** in **CHPAB** concept have high efficienty, low weight, ***without any residues***, are mobile, blended with biomass from local sources, produce **AgriBIOCHAR** incorporated in agricultural land, contribute to their productive potential, to sustainable development and are financially accessible for agricultural farms and isolated communities.

CONCLUSIONS

5. The **CHPAB** system analyzed to produce **1 MWhe** with an efficiency of 11.5% and **282 kg**. **AgriBIOCHAR** with 23.5% efficiency consumed **1,877 tone biomass** with humidity of 10% and produced **2.24 MWhth** of **thermal** energy with an efficiency of 27.8% on a negative carbon footprint of **- 233 kg**.C/MWhe.

Was presented:

For a circular economy -
Heat, Power and Biochar
from agricultural and forestry residual biomass

Spre o economie circulară –
Căldură, Electricitate și Biochar
din biomasă reziduală agricolă și forestieră

Thank for your attention !!!

Brasov 31 may 2019