

## POWER PRODUCTION A NEGATIVE CARBON BALANCE WITH CHAB CONCEPT

Erol MURAD

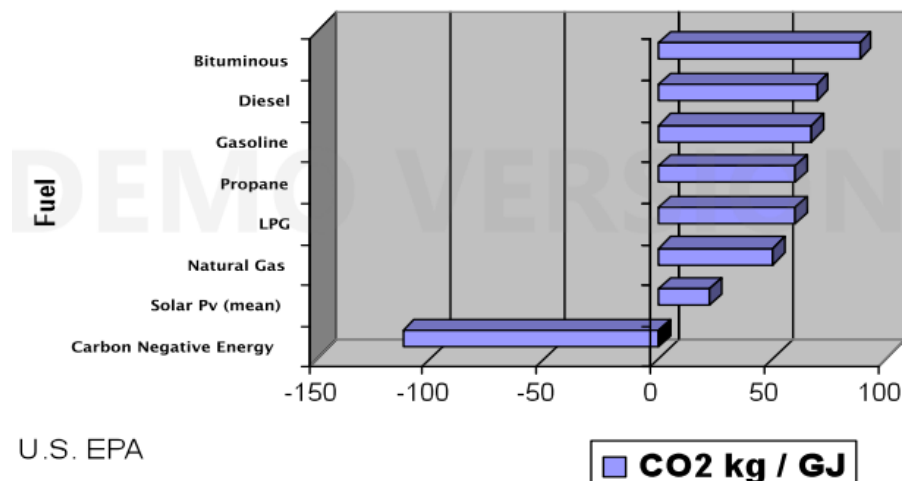
SC EKKO OFFICE AG, erolmurad@yahoo.com

**Abstract:** The paper analyzes the production of electricity with carbon negative balance from local biomass gasified with TLUD process which produces 15% biochar that is incorporate in agricultural soil. They compared the CO<sub>2</sub> emissions of a gasoline-powered electric generator HONDA and syngas-powered produced a TLUD gasifier. It follows an absolute emission of CO<sub>2</sub> in the environment only 22.3 g.CO<sub>2</sub>/kWh, 2% of emissions from gasoline. Biochar incorporated in agricultural soil sequesters -2,428 kg.CO<sub>2</sub>/kWh, contribute to increased fertility and agricultural crop production.

**Keywords:** negative carbon balance, biomass, CHAB concept

### 1. Introduction

Production of heat and electricity with biomass gasifiers is known in the World War II could work more than one million vehicles powered by wood or charcoal gasifiers. Currently imposing the requirements of sustainable development was returned to biomass gasification technique to another level of knowledge and technology to produce energy with zero or negative balance of CO<sub>2</sub>. For example is the graphic presented in figure 1. [1, 2, 3, 7, 8]



**Fig. 1.** Agricultural use offers Carbon Negative Energy  
{Stefan Czernick (NREL) and Mathew Realf (Ga Tech)}

Sustainable development of agriculture requires more green energy and maintaining and enhancing the productive capacity of the soil, the as low as possible use of mineral fertilizers in favour of compost, The which correlated with the present environmental requirements results in the need to increase the residual biomass generated by agricultural activities. [1, 3, 4, 6]

As an alternative to current methods of thermal energy production from biomass it is proposed the CHAB (Combined Heat And Biochar production) concept which includes also the biochar (BC) generation. BC is a sterile organic material obtained from biomass pyrolysis in an oxygen-free environment or with a sub stoichiometric concentration, with alkaline pH. It has a carbon content of 80-95% and it is characterized by high porosity and adsorption capacity. [3, 4, 5, 6, 12]

The biomass gasification in CHAB concept uses the biochar byproduct gasification during power generation, as the carbon store that can be collected and sequestered. Sequestration is much easier than flue stack CO<sub>2</sub> gas capture and storage, as char is a solid and easy to handle. Biochar is equally important as a soil amendment, with surprisingly powerful benefits to plant productivity, soil biological activity, water retention, pest management and mineral uptake in plants. And as it is known to be stable in soil for 100s to 1000s of year timeframes, it is a low tech and cheap method for carbon storage, already with a scaled infrastructure via global agriculture. [1, 3, 4, 7, 8, 15, 16]

Generating electricity from biomass, such as urban waste and sustainably-sourced forest and crop residues, is carbon-neutral: it produces as much carbon as the plants suck out of the atmosphere. Examples are the current achievements of the ALL POWER LABS, V-GRID ENERGY SYSTEMS, DIARBON, ECOERA and EPRIDA. [11, 15, 16, 17, 18]

V-GRID ENERGY SYSTEMS has developed a 100 kW generator that runs on farm waste biomass and can generate electricity for as  $\approx 0.02$  per kWh. In contrast, farm utility power in California average  $\approx 0.15$  and diesel costs over  $\approx 0.20$  per kWh. Solar require a 10 year + commitment whereas our mobile system require just a few month lease trial. Our systems can also co-produce biochar soil enhancers optimized for farm's needs. [18]

The below is an example of a 500 kW V-Grid Server Array, figure 2, with one month capacity fuel silo for 24/7 on-demand power. V-Grid's Bioenergy Servers can be both mobile and stationary. Each Bioenergy Server consists of a gasifier and a generator pairing, that can be deployed to remote well sites or be linked together into an array to produce 24/7 on-demand power for large scale operations. [18]

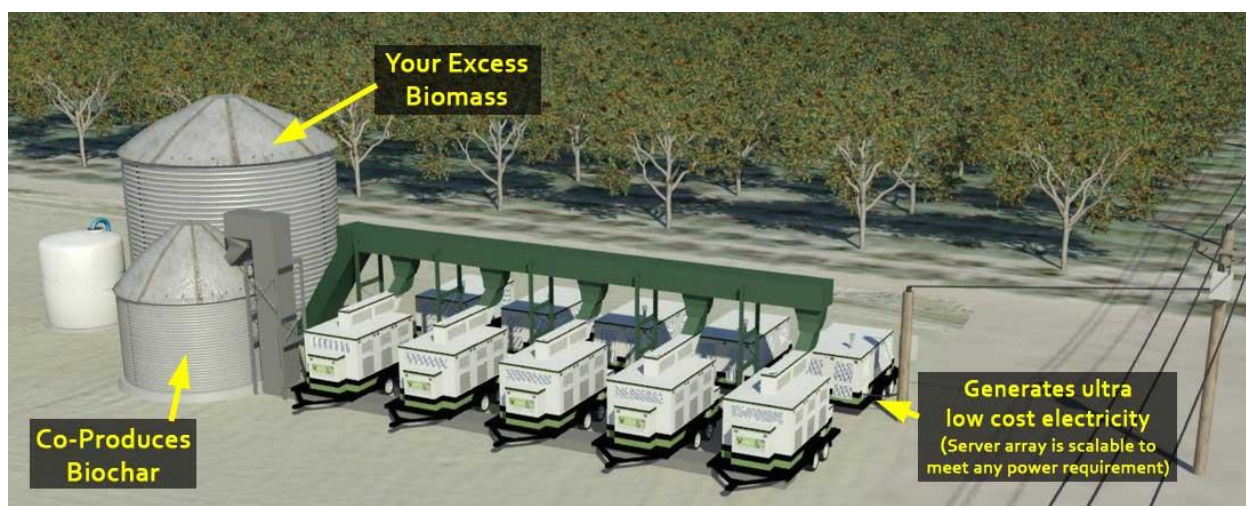


Fig. 2. V-GRID power station generating 500 kW V-GRID on a farm

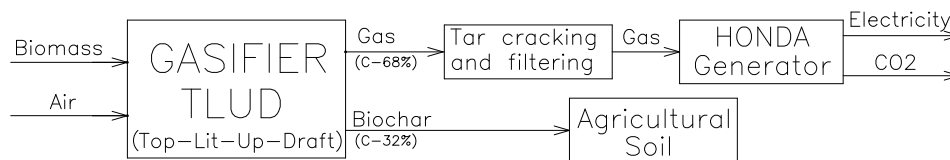
Recent development by EPRIDA, Inc. has made this technology more scalable to agricultural industries with two sizes of pyrolysis units. The first processes 1-ton of biomass per hour unit and produces 1 MWe of electricity, 1 MWth of usable heat and 136 kg. biochar per hour. The second processes 25 kg of biomass per hour, producing 25 kWth of heat and 25 kWe of electricity and 9 kg. biochar per hour. The Eprida process was developed through research conducted with the National Renewable Energy Labs, Oak Ridge National Laboratory, the Pacific Northwest National Laboratory, U.S. Dept. of Energy, USDA EPRIDA, Inc Agricultural Research Service, University of Georgia and Iowa State University. [15]

Most gardeners and farmers would excitedly embrace any method that results in increasing their yields by even a few percentage points. The results of Diacarbon's initial growth trials that studied the application of biochar to tomato plants should truly give them reason to celebrate. Recently, Diacarbon's research and development team showcased our biochar in a few landmark growth trials that revealed dramatic improvements in plants survival alongside yield increases of nearly 70%. [16]

## 2. Material and method

For example compares the production of electricity with a generator type **HONDA EU3000i Handi** supply with syngas from gasifier TLUD in a concept CHAB. [5, 10, 14]

In figure 3 shows the block diagram of the Honda electric generator syngas powered.



**Fig. 3.** Block diagram for power system with CHAB

Biomass is gasified with a TLUD process to produce syngas and biochar. It used a biomass derived from fruit prungins, shredded and dried to 15% moisture. To produce syngas with very little tar the temperature migratory pyrolysis front is maintain of over 700 C, leading to a ratio of only 15% of high quality biochar. The characteristics of the processed biomass gasified with TLUD are shown in table 1. [6, 9, 10]

**TABLE 1:** Shredded biomass from gasification

Feature	M.U.	Shredded biomass	Biochar	Gasified biomass
<i>Relative masse</i>	real	1,0000	0,1500	0,8500
Carbon	real	0,4081	0,8729	0,3261
Oxygen	real	0,3796	0,0255	0,4421
Hydrogen	real	0,0503	0,0216	0,0553
Ash	real	0,0120	0,0800	0,0000
Humidity	real	0,1500	0,0000	0,1765
L.H.V	MJ/kg	<b>15,3000</b>	<b>25,5061</b>	<b>13,4990</b>
Carbon content	%	100,0000	32,08	67,92
Energy content	%	100,0000	25,0100	74,9900
CO2 foot print	kg.CO2/kWhth	0,00522	0	0
CO2 foot print	kg.CO2/kg	0,022185	0,019365	0,0072341

(th – thermic)

As analyzing CO2 emissions are taken in computing and specifically carbon foot print (kg.CO2/kg.bm) product harvesting, chopping and drying, which are then distributed to gasified biomass and biochar. [13, 19]

**TABLE 2:** Gasifier in CHAB concept

Feature	M.U.	Value
LHV cold syngas	MJ/Nm <sup>3</sup>	3,800
Syngas density	kg.gas/Nm <sup>3</sup>	1,192
Carbon in syngas	kg.C/Nm <sup>3</sup> .gas	0,130
Specifique biochar production	kg.bc/Nm <sup>3</sup> .gas	0,148
Carbon in biochar	kg.C/kg.bc	0,873
CO2 specifique foot print	kg.CO2/Nm <sup>3</sup> .gas	2,857E-03

(bc – biochar; gas – syngas)

Gasification regime is optimal to a ratio  $A/F = 1.5$ , which produces 2.15 kg.gas with molar mass of 26.7 kg.gas/mole and density of 1.192 kg.gas/Nm<sup>3</sup> and LHV of 3.8 MJ/Nm<sup>3</sup>. [5, 9, 10]

From gasifier there result syngas and biochar. Carbon from biomass is distributed 68% in syngas and 32% in biochar. The datas is presented in table 2.

Syngas is tar craching, filtering and supplies the generator engine. Biochar is cooled, minced and inserted into the in agricultural soil.

### 3. Results and discussions

Gasoline powered HONDA electric generator has a specific consumption of 0.313 kg.g/kWhe leading to a specific CO<sub>2</sub> emission of 1.110 kg.CO<sub>2</sub>/kWhe; data are presented in table 3.

**TABLE 3:** HONDA generator gasoline powered

Feature	M.U.	Value
HONDA Power (nominal)	kWe	2,800
LHV gasoline	MJ/kg.g	42,700
Specifique emission	kg.CO <sub>2</sub> /kWth	0,299
Specifique emission	kg.CO <sub>2</sub> /kg.g	3,546
Specifique gasoline consum	kg.g/kWhe	0,313
HONDA Specific CO <sub>2</sub> emission	kg.CO <sub>2</sub> /kWhe	<b>1,110</b>

(g – gasoline ; e -electric)

In order to calculate CO<sub>2</sub> emission has been reported syngas carbon used in thermal engine which was added the carbon foot print. [13, 19]

Syngas supply follows a specific emission of 2,450 kg.CO<sub>2</sub>/kWhe higher than that of gasoline use since these it contains more hydrogen and a better thermal efficiency.

Biochar from biomass to produce 1 kWhe introduced in agricultural soil leads to a negative balance of 2.428 kg.CO<sub>2</sub>/kWhe, very close to the emission from engine. It follows that in environment balance sheet total is 22.3 g.CO<sub>2</sub>/kWhe, ie 2% of emissions from gasoline.

Given the nature in carbon cycle, where CO<sub>2</sub> and solar energy are transformed in biomass through photosynthesis and biomass consumed regenerate a balance resulting final -5,988 kg.CO<sub>2</sub>/kWhe, which proves that real power is produced with negative carbon balance.

Consumption data of syngas powered HONDA electric generator is in table 4.

**TABLE 4:** HONDA generator syngas-powered

Feature	M.U.	Value
ICE yeld with syngas	real	0,200
Electric generator yeld	real	0,930
Global yeld	real	0,186
Specifique syngas consum	Nm <sup>3</sup> /kWhe	5,093
Specifique CO <sub>2</sub> emission	kg.CO <sub>2</sub> /kWhe	2,450
CO <sub>2</sub> retention in soil from biochar	kg.CO <sub>2</sub> /kWhe	-2,428
Total CO <sub>2</sub> balance	kg.CO <sub>2</sub> /kWhe	0,0223
CHAB/gasoline emissions	%	<b>2,014</b>
CO <sub>2</sub> balance with photosynthesis	kg.CO <sub>2</sub> /kWhe	<b>-5,988</b>

#### 4. Conclusions

By using biomass for power production with CHAB concept can produce electrical energy and biochar with a negative carbon balance in environment, which leads to a CHP concept with a negative carbon balance without CO<sub>2</sub> sequestration.

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Biochar inserted into the in agricultural soil sequester between 25 and 40% of the carbon from biomass, reducing CO<sub>2</sub> emissions in environmental and enhancing soil fertility which substantial increase of the food production.

Plants producing electricity with carbon negative balance from local biomass supply can provide real energy independence in isolated areas.

The results are in good correlation with the data from figure 2 which indicates that the analyzed constructive solution fits into the trend of producing energy with negative carbon balance.

The analysis carried out involves aspects of the local and global variation of entropy, a subject that will be analyzed in the following studies.

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