ELECTRONIC SUPPLEMENTARY MATERIAL OF:

Life Cycle Assessment of a Wood Biomass Gasification Plant and Implications for Syngas and Biochar Utilization

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Table S1. List of the flows involved in the examined system (LCI).

Step		Flow	Amount	Unit
Chipping + Drying	IN	Cleft timber	112.31	kg
		Heat	20.88	kWh
		Electricity	0.50	kWh
	OUT	Dried wood	86.39	kg
		Dust	1.39	kg
I Feeding + Storage	IN	Wood chips	85.00	kg
		Electricity	0.38	kWh
	OUT	Anhydrous wood chips	78.20	kg
		Water (moisture)	6.80	kg
II Reactor	IN	Anhydrous wood chips	78.20	kg
		Air	119.26	kg
		Electricity	0.82	kWh
	OUT	Anhydrous syngas	194.53	kg
		Coal	2.92	kg
III Exchanger	IN	Anhydrous syngas	194.53	kg
		Coal	2.92	kg
		Electricity	1.17	kWh
	OUT	Anhydrous syngas	194.53	kg
		Coal	2.92	kg
		Heat	41.12	kWh
IV Filtering	IN	Anhydrous syngas	194.53	kg
		Coal	2.92	kg
		Electricity	1.48	kWh
	OUT	Anhydrous syngas	194.53	kg
		Coal	2.92	kg
V Char unloading and storage	IN	Coal	2.92	kg
		Electricity	0.37	kWh
	OUT	Biochar	2.92	kg
VI Exchanger 2	IN	Anhydrous syngas	194.53	kg
		Electricity	0.94	kWh
	OUT	Anhydrous syngas	194.53	kg
Vii Syngas blower	IN	Anhydrous syngas	194.53	kg
		Electricity	4.29	kWh
	OUT	Anhydrous syngas	194.53	kg
VIII Motor	IN	Anhydrous syngas	194.53	kg
		Air	119.26	kg
		Electricity	0.94	kWh
	OUT	Electricity	-85.00	kWh
		Heat	-160.00	kWh

Table S2. Scores are assigned with the pedigree matrix to each specific flow and standard deviation calculated per each flow.

	Electricity		Heat		Input wood		Energy drying	
U1 (reliability)	1.00	0	1.00	0	1.10	9.1E-03	1.20	3.3E-02
U2 (completeness)	1.00	0	1.00	0	1.00	0	1.10	9.1E-03
U3 (temporal c.)	1.00	0	1.00	0	1.00	0	1.03	8.7E-04
U4 (geographical c.)	1.00	0	1.00	0	1.00	0	1.05	2.4E-03
U5 (technological c.)	1.00	0	1.00	0	1.00	0	1.50	1.6E-01
Ub	1.05	2.4E-03	1.05	2.4E-03	1.05	2.4E-03	1.05	2.4E-03
SD		1.1E+00		1.1E+00		1.1E+00		1.6E+00

Table S3a. Life Cycle Impact Assessment of the three scenarios estimated for the 18 ReCiPe midpoint categories and Single Score.

Step	Scenario	GWP	ODP	IRP	HOFP	PMFP	EOFP	TAP	FEP	MEP	TETP
Chipping + drying	1 and 2	5.14E+00	3.97E-06	1.02E-01	2.44E-02	5.81E-03	2.60E-02	1.46E-02	3.00E-03	5.20E-04	1.46E+00
(I) Feeding + storage	all	1.57E-01	1.25E-07	5.59E-03	2.41E-04	1.30E-04	2.42E-04	3.86E-04	3.08E-05	3.25E-06	3.13E-02
(II) Reactor	all	3.36E-01	2.68E-07	1.20E-02	5.15E-04	2.79E-04	5.17E-04	8.26E-04	6.60E-05	6.95E-06	6.70E-02
(III) Exchanger	Baseline	-1.07E+01	-2.07E-06	-1.31E-01	-5.22E-03	-2.40E-03	-5.33E-03	-7.02E-03	-3.28E-04	-3.44E-05	1.53E-02
(III) Exchanger	1 and 2	-5.05E+00	-8.26E-07	-5.59E-02	-2.20E-03	-9.82E-04	-2.25E-03	-2.86E-03	-1.14E-04	-1.19E-05	5.59E-02
(IV) Filtering	all	6.05E-01	4.82E-07	2.15E-02	9.27E-04	5.01E-04	9.30E-04	1.49E-03	1.19E-04	1.25E-05	1.21E-01
(V) Char unloading and storage	Baseline and 1	-1.68E+00	1.26E-07	5.71E-03	3.16E-04	1.51E-04	3.17E-04	4.21E-04	3.24E-05	3.33E-06	3.11E-02
(V) Char unloading and storage	2	-1.68E+00	1.26E-07	5.71E-03	3.16E-04	1.51E-04	3.17E-04	4.21E-04	3.24E-05	3.33E-06	3.11E-02
(VI) Exchanger 2	all	3.83E-01	3.05E-07	1.36E-02	5.87E-04	3.18E-04	5.89E-04	9.41E-04	7.52E-05	7.92E-06	7.63E-02
(VII) Syngas blower	all	1.76E+00	1.40E-06	6.25E-02	2.69E-03	1.46E-03	2.70E-03	4.32E-03	3.45E-04	3.63E-05	3.50E-01
(VIII) Motor	all	-7.81E+01	-3.70E-05	-1.80E+00	-7.59E-02	-3.95E-02	-7.65E-02	-1.16E-01	-8.40E-03	-8.84E-04	-7.17E+00
Total	Baseline	**-8.29E+01**	**-3.63E-05**	**-1.81E+00**	**-7.58E-02**	**-3.90E-02**	**-7.66E-02**	**-1.15E-01**	**-8.06E-03**	**-8.48E-04**	**-6.48E+00**
SD	Baseline	*5.39E+00*	*9.17E-06*	*2.90E+00*	*8.90E-03*	*3.52E-03*	*8.92E-03*	*1.06E-02*	*9.48E-03*	*1.39E-04*	*6.22E+00*
Total	1	**-7.64E+01**	**-3.11E-05**	**-1.63E+00**	**-4.84E-02**	**-3.18E-02**	**-4.75E-02**	**-9.64E-02**	**-4.85E-03**	**-3.06E-04**	**-4.98E+00**
SD	1	*4.82E+00*	*7.09E-06*	*2.09E+00*	*6.18E-03*	*3.11E-03*	*6.01E-03*	*9.59E-03*	*5.17E-03*	*5.24E-05*	*5.87E+00*
Total	2	**-7.44E+01**	**-3.11E-05**	**-1.63E+00**	**-4.84E-02**	**-3.18E-02**	**-4.75E-02**	**-9.64E-02**	**-4.85E-03**	**-3.06E-04**	**-4.98E+00**
SD	2	*4.87E+00*	*6.68E-06*	*2.02E+00*	*6.00E-03*	*2.96E-03*	*5.83E-03*	*9.22E-03*	*4.36E-03*	*5.37E-05*	*5.59E+00*

Table S3b. Life Cycle Impact Assessment of the three scenarios estimated for the 18 ReCiPe midpoint categories and Single Score.

Step	Scenario	FETP	METP	HTPc	HTPnc	LOP	SOP	FFP	WCP	SS
Chipping + drying	1 and 2	5.44E-03	7.11E-03	1.17E-02	7.23E-02	7.41E+01	8.24E-03	1.60E+00	3.79E-02	3.31E+02
(I) Feeding + storage	all	9.30E-05	1.52E-04	1.33E-05	6.40E-04	3.67E-02	1.61E-04	5.06E-02	3.08E-03	5.28E+00
(II) Reactor	all	1.99E-04	3.24E-04	2.84E-05	1.37E-03	7.85E-02	3.44E-04	1.08E-01	6.59E-03	9.15E+00
(III) Exchanger	Baseline	-2.62E-03	-3.68E-03	-3.10E-03	-1.55E-02	-2.74E-04	-4.18E-03	-3.66E+00	2.05E-03	-2.10E+02
(III) Exchanger	1 and 2	-1.14E-03	-1.58E-03	-1.50E-03	-6.62E-03	5.66E-02	-1.81E-03	-1.73E+00	5.77E-03	-9.66E+01
(IV) Filtering	all	3.58E-04	5.84E-04	5.11E-05	2.46E-03	1.41E-01	6.19E-04	1.95E-01	1.19E-02	1.65E+01
(V) Char unloading and storage	Baseline and 1	4.76E-03	3.98E-03	8.88E-03	4.50E+01	3.79E-02	2.55E-04	5.19E-02	3.02E-03	1.40E+02
(V) Char unloading and storage	2	2.68E-03	2.26E-03	4.88E-03	2.25E+01	3.79E-02	2.55E-04	5.19E-02	3.02E-03	5.42E+01
(VI) Exchanger 2	all	2.27E-04	3.70E-04	3.23E-05	1.56E-03	8.94E-02	3.92E-04	1.23E-01	7.51E-03	1.04E+01
(VII) Syngas blower	all	1.04E-03	1.70E-03	1.48E-04	7.15E-03	4.10E-01	1.80E-03	5.66E-01	3.44E-02	4.78E+01
(VIII) Motor	all	-3.17E-02	-4.93E-02	-1.51E-02	-2.08E-01	-8.47E+00	-5.34E-02	-2.59E+01	-7.03E-01	-1.80E+03
Total	Baseline	-2.76E-02	-4.59E-02	-9.06E-03	4.48E+01	-7.68E+00	-5.40E-02	-2.85E+01	-6.35E-01	-1.78E+03
SD	Baseline	*1.53E-02*	*2.26E-02*	*9.03E-03*	*6.13E-02*	*9.07E-01*	*6.04E-03*	*2.41E+00*	*2.93E+01*	*1.51E+03*
Total	1	-2.07E-02	-3.67E-02	4.27E-03	4.49E+01	6.64E+01	-4.34E-02	-2.50E+01	-5.93E-01	-1.34E+03
SD	1	*1.63E-02*	*2.49E-02*	*4.90E-03*	*8.04E-02*	*8.24E+00*	*5.10E-03*	*2.13E+00*	*8.41E+02*	*1.48E+03*
Total	2	-2.28E-02	-3.84E-02	2.74E-04	2.24E+01	6.64E+01	-4.34E-02	-2.50E+01	-5.93E-01	-1.43E+03
SD	2	*1.15E-02*	*1.78E-02*	*2.34E-04*	*5.72E-02*	*8.34E+00*	*4.86E-03*	*2.28E+00*	*3.12E+01*	*1.45E+03*

Figure S1. Life Cycle Impact Assessment of the three scenarios estimated for the 18 ReCiPe midpoint categories and Single Score.

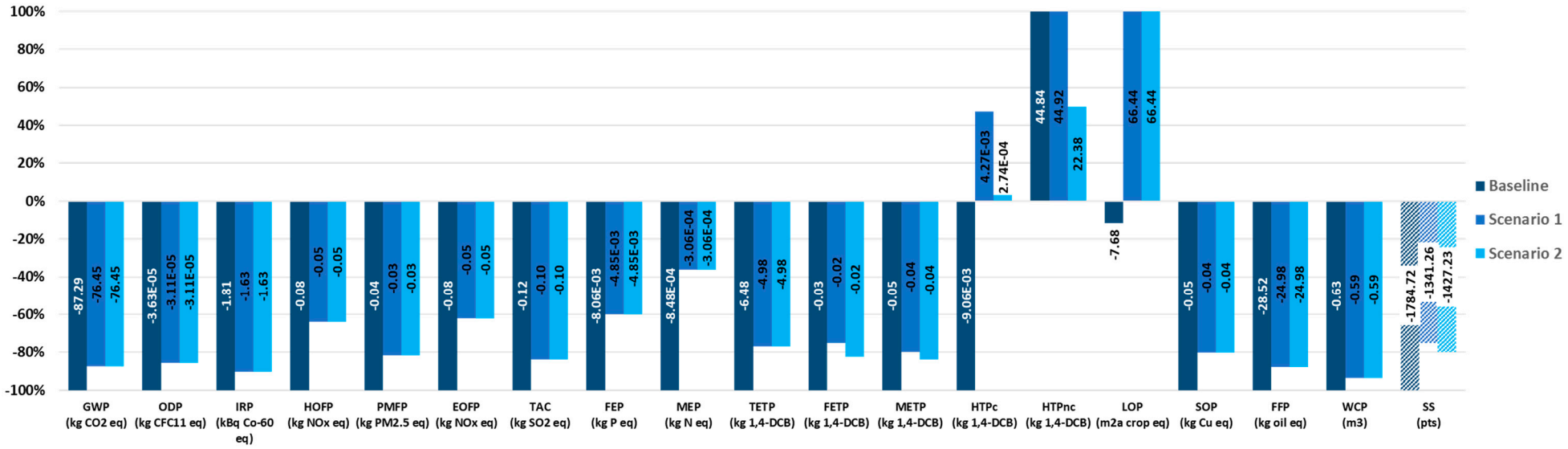

Table S4. Hotspot analysis related to the biochar UOL.

	EBC Agro (g/t_{DM})					**EBC AgroBio (g/tDM)**				
	TETP (kg 1,4-DCB/FU)	**FETP** (kg 1,4-DCB/FU)	**METP** (kg 1,4-DCB/FU)	**HTPc** (kg 1,4-DCB/FU)	**HTPnc** (kg 1,4-DCB/FU)	**TETP** (kg 1,4-DCB/FU)	**FETP** (kg 1,4-DCB/FU)	**METP** (kg 1,4-DCB/FU)	**HTPc** (kg 1,4-DCB/FU)	**HTPnc** (kg 1,4-DCB/FU)
Pb	1.48E-20	5.27E-04	2.86E-04	1.14E-01	1.26E+02	5.54E-21	1.98E-04	1.07E-04	4.27E-02	4.73E+01
Cd	5.51E-20	1.56E-03	1.07E-03	1.65E-01	1.50E+02	2.57E-20	7.28E-04	4.98E-04	7.70E-02	7.00E+01
Cu	1.38E-17	3.28E-01	2.29E-01	0.00E+00	1.86E+00	9.66E-18	2.30E-01	1.60E-01	0.00E+00	1.30E+00
Ni	3.57E-18	8.20E-02	6.10E-02	2.38E+00	3.65E-01	1.78E-18	4.10E-02	3.05E-02	1.19E+00	1.83E-01
Hg	5.53E-21	1.99E-04	1.15E-04	2.94E-02	1.17E+01	2.21E-21	7.96E-05	4.60E-05	1.18E-02	4.68E+00
Zn	4.84E-17	1.13E+00	9.64E-01	0.00E+00	1.51E+04	2.42E-17	5.64E-01	4.82E-01	0.00E+00	7.54E+03
Cr	1.79E-18	3.76E-02	2.48E-02	0.00E+00	7.07E-04	1.39E-18	2.93E-02	1.93E-02	0.00E+00	5.50E-04
As	2.51E-19	6.20E-03	5.20E-03	4.08E-01	8.52E+01	2.51E-19	6.20E-03	5.20E-03	4.08E-01	8.52E+01
Total	6.79E-17	1.58E+00	1.29E+00	3.09E+00	1.55E+04	3.73E-17	8.71E-01	6.98E-01	1.73E+00	7.75E+03

Equations (S1)–(S3). Sensitivity analysis related to the inbound transportation of wood.

$$\Delta \boldsymbol{GWP} = GWP_{Scenario1} - GWP_{Baseline} = -76.45\ \mathrm{kgCO_2eq} - (-87.29\ \mathrm{kgCO_2eq}) \quad \textbf{(S1)}$$

$$= \mathbf{10.84\ kgCO_2\ eq}$$

$$\Delta \boldsymbol{tkm} = \frac{\Delta GWP}{I_{1\mathrm{tkm}}} = \frac{10.84\ \mathrm{kg\ CO_2eq}}{0.21\ \frac{\mathrm{kg\ CO_2eq}}{\mathrm{tkm}}} = \mathbf{50.59\ tkm} \quad \textbf{(S2)}$$

$$\boldsymbol{BED} = \frac{\Delta tkm}{FU} = \frac{50.59\ \mathrm{tkm}}{0.085\ \mathrm{t}} = \mathbf{595.21\ km} \quad \textbf{(S3)}$$

(1) Computation of ΔGWP → where, $GWP_{Scenario1}$ and $GWP_{Baseline}$ are the GWP estimated for Scenario 1 and Baseline Scenario, respectively.

(2) Amount of tkm that corresponds to the ΔGWP → where, Δtkm represent the amount of tkm which corresponds to the ΔGWP, by assuming a unitary impact of 0.21 $\frac{\mathrm{kg\ CO_2eq}}{\mathrm{tkm}}$.[1]

(3) Computation of the breakeven distance to balance the GWP impact of Baseline and Scenario 1 → where BED is the breakeven distance that must be traveled to allow the Baseline GWP to reach the Scenario 1 GWP. FU still represents the functional unit of 85 kg of inflow wood.

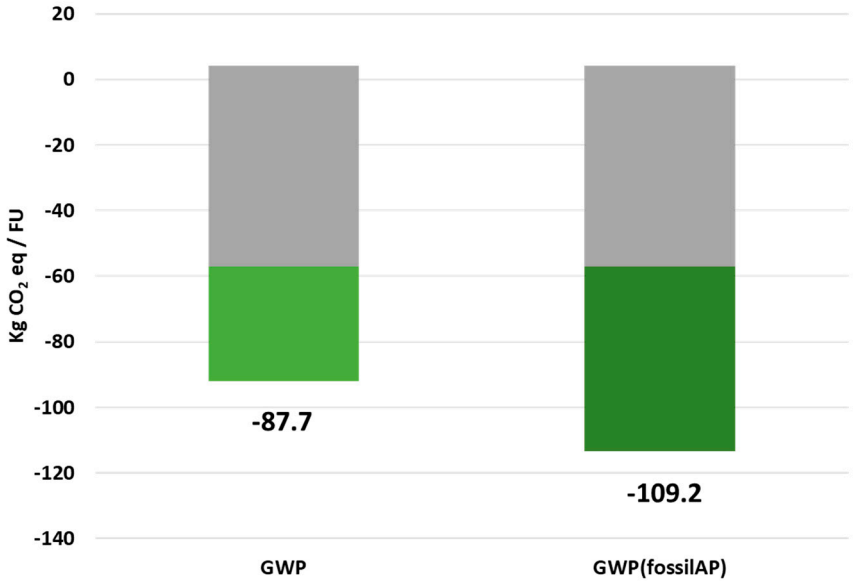

Figure S2. Comparison between the GWP of the baseline scenario (GWP) and the GWP by assuming that the electricity avoided would be completely derived from fossil resources (GWPfossilAP).