



**INTERNATIONAL BIOMASS
TORREFACTION COUNCIL**

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Agricultural Biomass Torrefaction: basic of the technology, main benefits, applications

Michael Wild
Wild&Partner LLC, Vienna, Austria
IBTC, Brussels, Belgium

Torrefaction of Agricultural Biomass
WEBINAR September 20th 2021
By IBTC and WBA

Full Members



INTERNATIONAL BIOMASS
TORREFACTION COUNCIL

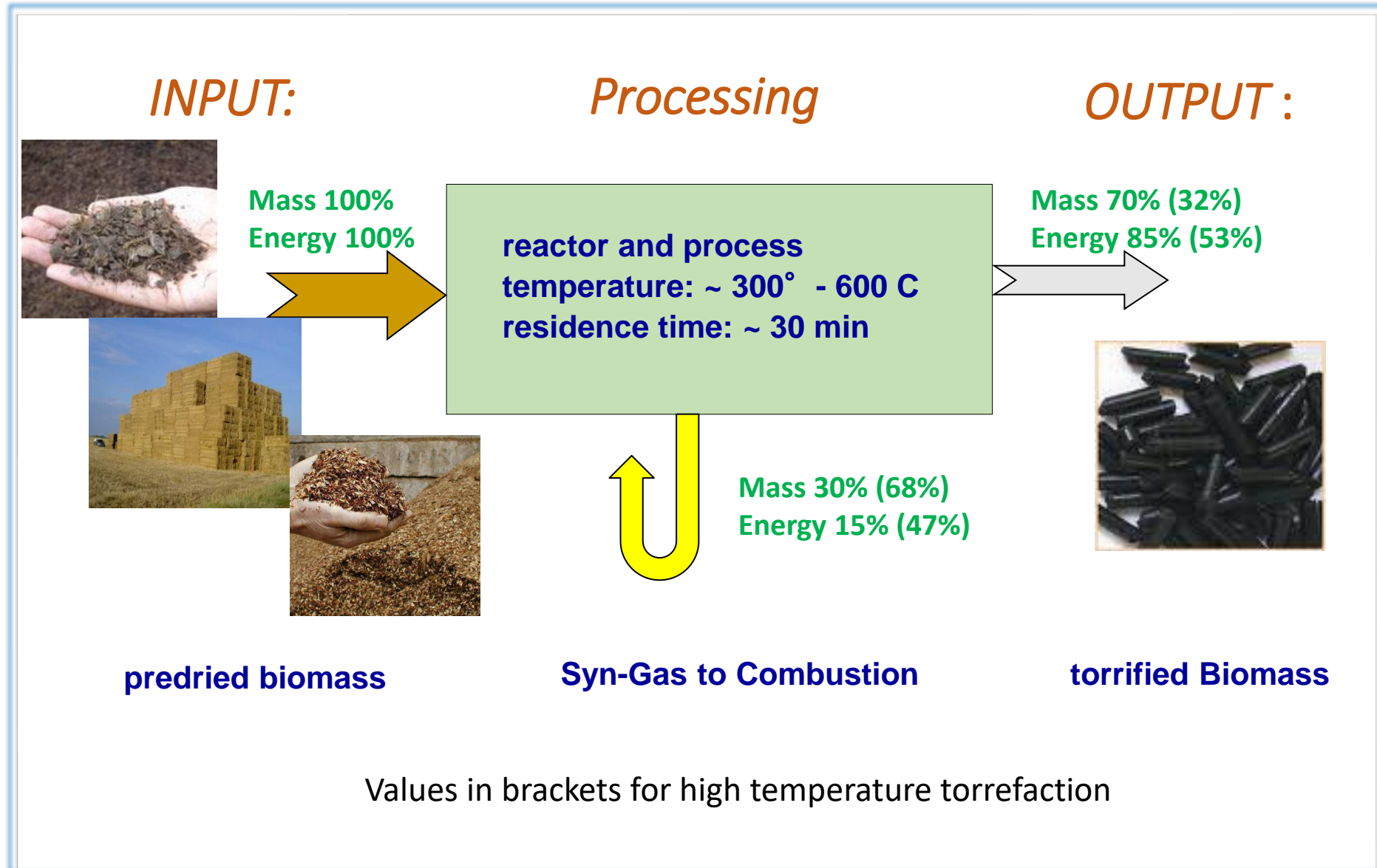
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Developing Members



Associated Members



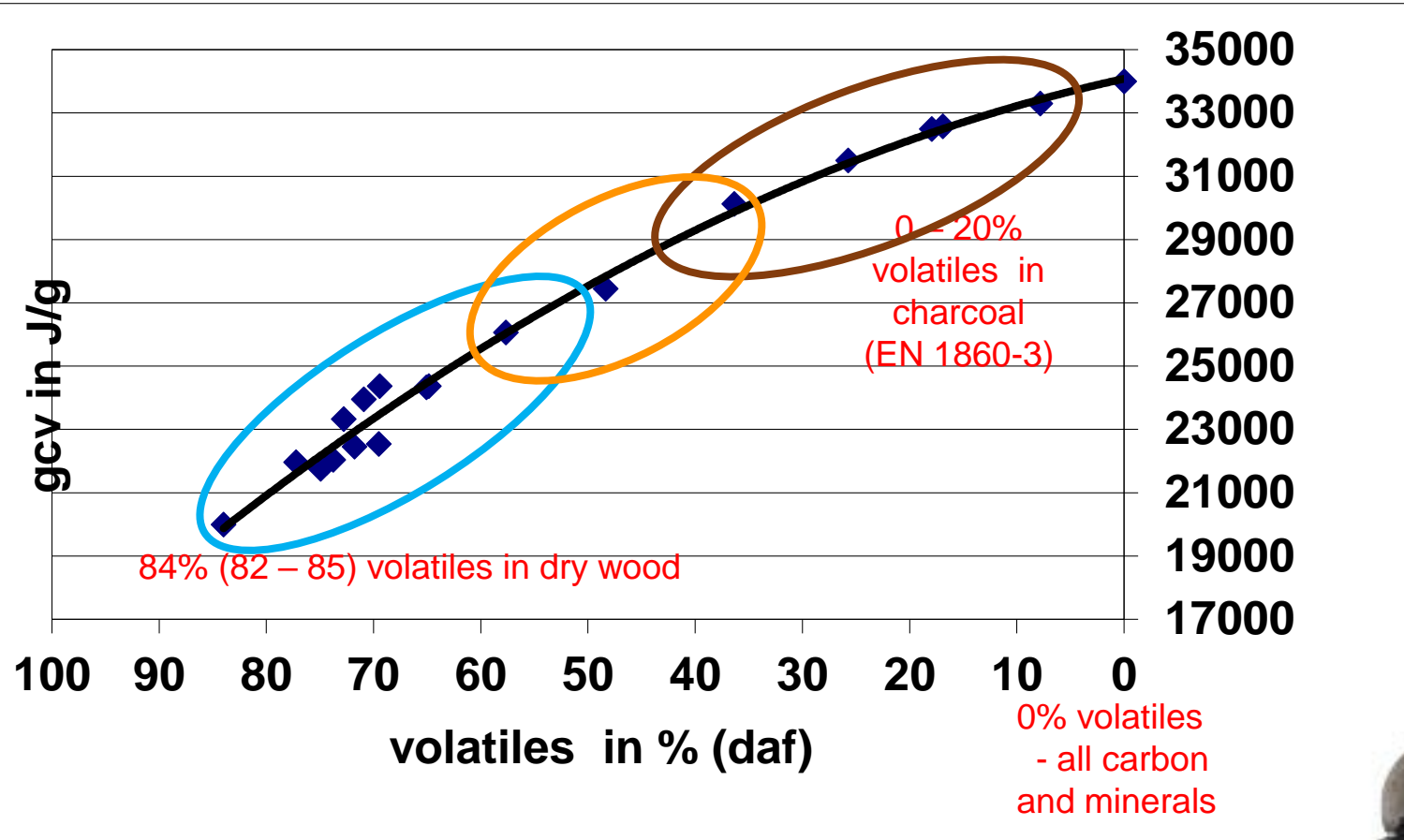


Products along the carbonization curve

Carbonisation

Pyrolyses

Torrefaction



Single or multiple step processes

9/22/2021

Thermochemical Gradient

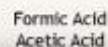
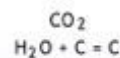
Hemicellulose

Cellulose

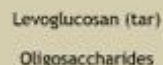
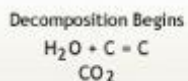
Lignin



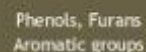
Dehydration Zone



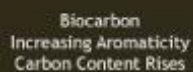
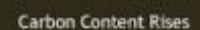
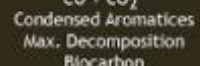
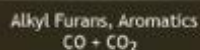
Retification Zone



Torrefaction Zone

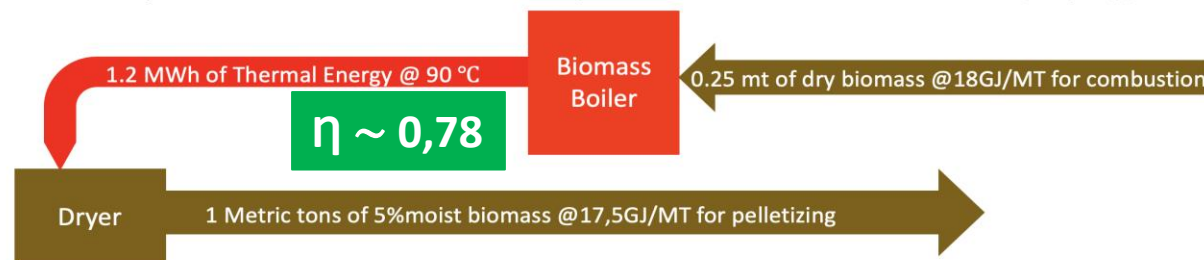


Carbonization Zone



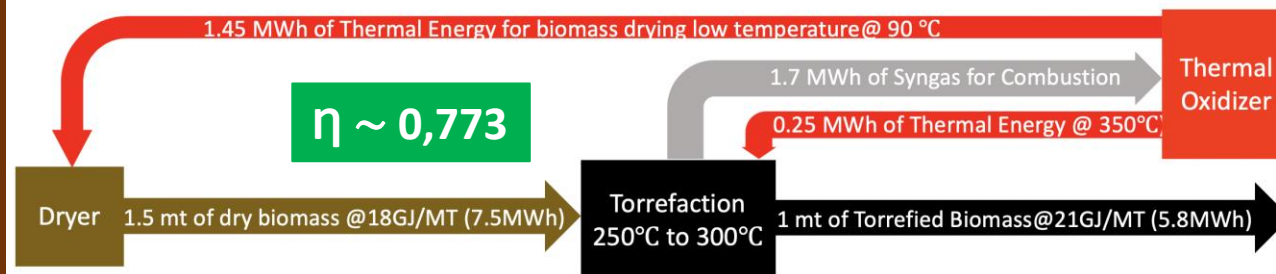
WHITE WOOD PELLET

To produce 1 metric ton of White Wood Pellets with an energy content of $\sim 17 \text{ GJ/mt}$ we require ~ 1.24 metric tons of dry biomass @ 18 GJ/metric ton (drying)



TORREFACTION

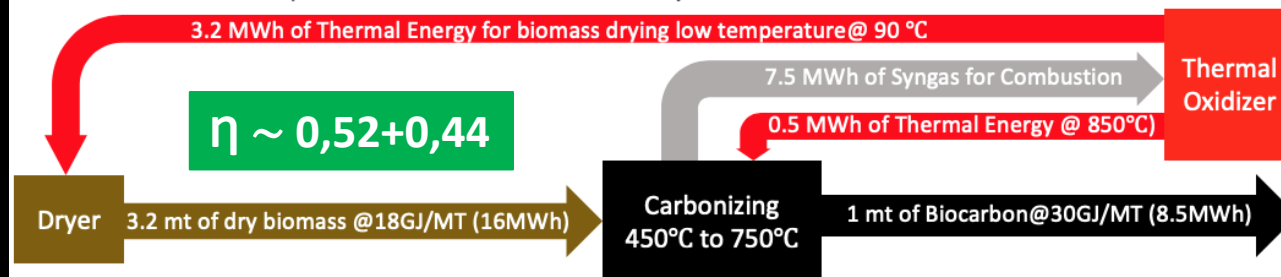
To produce 1 metric ton of torrefied biomass with an energy content of $>21 \text{ GJ/mt}$ we require ~ 1.5 metric tons of dry biomass @ 18 GJ/metric ton (30% mass reduction)



AUTOTHERMAL PROCESS

CARBONIZATION

To produce high energy Biocarbon with an energy content of $>30 \text{ GJ/mt}$ we require 3.2 metric tons of dry biomass @ 18 GJ/metric ton

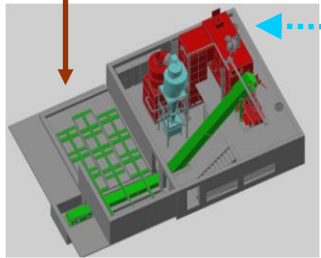


AUTOTHERMAL + 7 MWh of Thermal Energy for production of 1.4 MWh of Electricity

The torrefaction process

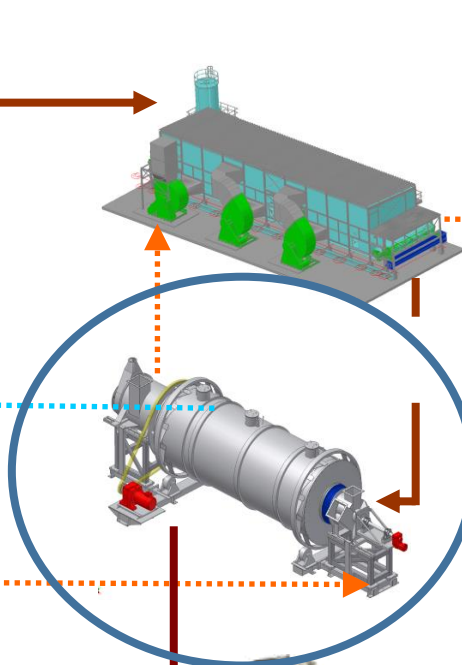
Fresh biomass

Fresh biomass fuel



ENERGY SUPPLY

Biomass +
lean gas incineration



Drum drier or calziner

Auger-screw type reactor

Vibrating belt

Multiple Hearth

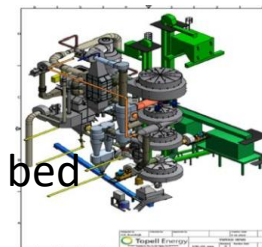
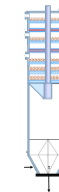
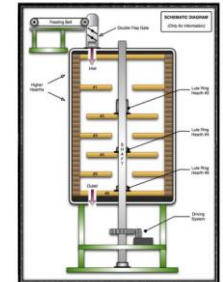
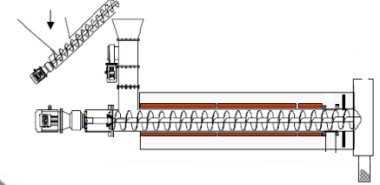
Pressurised

Moving bed reactor

Cyclone,
Fluidized bed



also Micro wave
supplemented



Co-current
Counter current



Feedstock Flexibility

The thermal treatment of the biomass during the torrefaction process can reduce the organically bound chlorine up to 90%

If thermal treatment alone is not sufficient to meet all product requirements, it is likely that the limiting factors can be eliminated with simple pre- or post-treatment.

By this Torrefaction is opening up the energy and biocarbon market for agricultural by products, grassy crops and other underutilized biomasses with unacceptable high Chlorine content

Bio-carbon fuel products

Advanced form factors



Pellets

6-12 mm



Agglomerated



Briquetted

(higher carbonized 12-50mm)

Diversity of Products and Markets

Volume Product	Fuel for Pulverized Coal Power Plants
Niche Product	Biochar Soil enhancer, Feedstock for Gasification
Upcoming markets:	Fuel for Heating application (DH, small CHP etc) Fuel for Process Energy Needs (High temp) Blast Furnace Reduction+Injection Carbon Carbon source for plastics industry Activated Carbon Products for new (niche) markets

We expect to see significant shifts in the importance of the individual markets

Quality – Standardisation

ISO 17225

Solid biofuels -Fuel specifications and classes

ISO TS 17225 - 8:

Part 8: Graded thermally treated and densified biomass fuels

Different Classes

1.1 Forest, plantation and other virgin wood

1.2 By-products and residues from wood processing industry

1.3.1 Chemically untreated used wood

2. Herbaceous biomass

3. Fruit biomass

4. Aquatic biomass

NCV, Durability, Bulk Density, Volatile Matter, Water sorption, Grindability etc.

TS upgrading to full Standard in process

ISO/TS 17225-8:2016
Table 2 — Specification of graded pellets produced by thermal processing of non-woody biomass

Property class, Analysis method	Unit	TA1	TA2	TA3
Normative				
Origin and source, ISO 17225-1 Table 1		2.1 Herbaceous biomass from agriculture and horticulture 2.2.1 By-products and residues from food and herbaceous processing industry, chemically untreated herbaceous residues 3.1 Orchard and horticulture fruit 3.2.1 By-products and residues from food and fruit processing industry, chemically untreated fruit residues 4. Aquatic biomass	2. Herbaceous biomass 3. Fruit biomass 4. Aquatic biomass	2. Herbaceous biomass 3. Fruit biomass 4. Aquatic biomass
Diameter, D ^a and Length L ^b , ISO 17829	mm	D06 to D25, D ± 1; 3,15 < L ≤ 40 (from D06 to D10) 3,15 < L ≤ 50 (from D12 to D25) M10 ≤ 10	D06 to D25, D ± 1; 3,15 < L ≤ 40 (from D06 to D10) 3,15 < L ≤ 50 (from D12 to D25) M10 ≤ 10	D06 to D25, D ± 1; 3,15 < L ≤ 40 (from D06 to D10) 3,15 < L ≤ 50 (from D12 to D25) M10 ≤ 10
In accordance with Figure 1				
Moisture, M ^c , ISO 18134-1, ISO 18134-2	w-% as received wet basis	A5.0 ≤ 5,0	A10.0 ≤ 10,0 DU96.5 ≥ 96,5	Value to be stated DU95.0 ≥ 95,0
Ash, A, ISO 18122	w-% dry	DU97.5 ≥ 97,5	F2.0 ≤ 2,0	F3.0 ≤ 3,0
Mechanical durability, DU, ISO 17831-1	w-% as received	F2.0 ≤ 2,0	Type and amount to be stated Q18 ≥ 18 or Q5.0 ≥ 5,0	Type and amount to be stated
Fines, F ^d , ISO 18846	w-% dry	Type and amount to be stated Q18 ≥ 18 or Q5.0 ≥ 5,0	Value to be stated BD600 ≥ 600	Value to be stated BD550 ≥ 550
Additives ^e				
Net calorific value, Q _{net} , ISO 18125	MJ/kg or kWh/kg as received	Value to be stated BD600 ≥ 600	Value to be stated	Value to be stated
Bulk density, BD, ISO 17828	kg/m ³ as received	Value to be stated	Value to be stated	Value to be stated
Carbon, C, ISO 16948	w-% dry	N1.5 ≤ 1,5	N2.0 ≤ 2,0	N2.5 ≤ 2,5
Nitrogen, N, ISO 16948	w-% dry	S0.1 ≤ 0,1	S0.2 ≤ 0,2	S0.3 ≤ 0,3
Sulfur, S, ISO 16994	w-% dry	Cl0.1 ≤ 0,1	Cl0.2 ≤ 0,2	Cl0.3 ≤ 0,3
Chlorine, Cl, ISO 16968	w-% dry	≤ 2	≤ 2	Value to be stated
Arsenic, As, ISO 16968	mg/kg dry	≤ 1	≤ 50	Value to be stated
Cadmium, Cd, ISO 16968	mg/kg dry	≤ 50	≤ 20	Value to be stated
Chromium, Cr, ISO 16968	mg/kg dry	≤ 20	≤ 10	Value to be stated
Copper, Cu, ISO 16968	mg/kg dry	≤ 10	< 0,1	Value to be stated
Lead, Pb, ISO 16968	mg/kg dry	< 0,1	≤ 10	Value to be stated
Mercury, Hg, ISO 16968	mg/kg dry	≤ 10	≤ 200	Value to be stated
Nickel, Ni, ISO 16968	mg/kg dry	≤ 200	Value to be stated	Value to be stated
Zinc, Zn, ISO 16968	mg/kg dry	Value to be stated	Value to be stated	Value to be stated
Volatile matter, VM, ISO 18123	w-% dry	Should be stated	Should be stated	Should be stated
Informative				
Ash melting behaviour ^f , ISO 21404	°C	Should be stated	Should be stated	Should be stated

ISO/TS 17225-8:2016
Table 3 — Specification of graded pellets produced by thermal processing of woody biomass

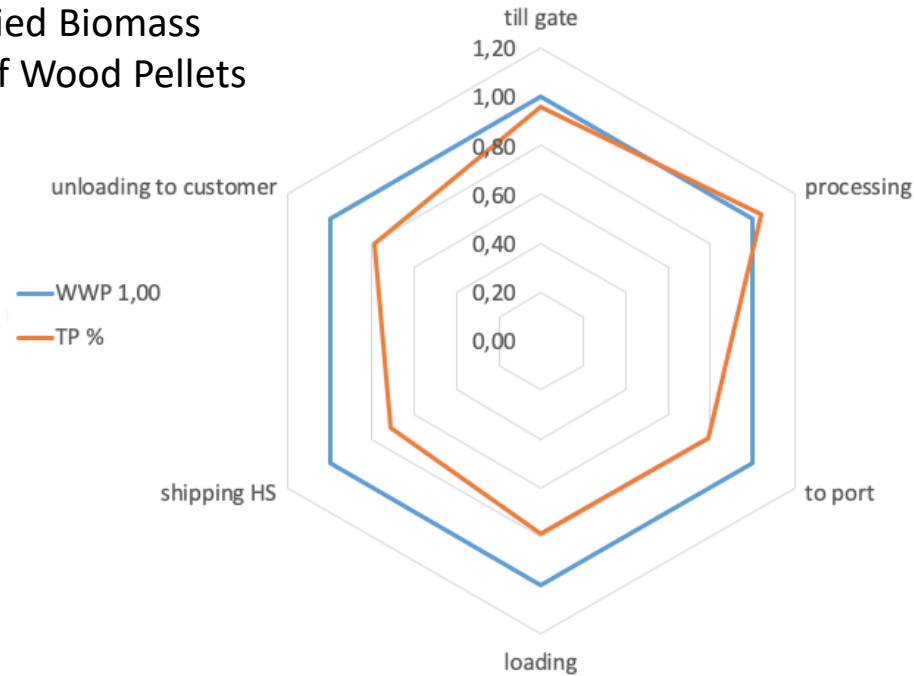
Property class, Analysis method	Unit	TW1H	TW1L	TW2H	TW2L	TW3H	TW3L
Normative							
Origin and source, ISO 17225-1 Table 1		1.1.1 Whole trees without roots 1.1.3 Stemwood 1.1.4 Logging residues 1.2.1 Chemically untreated wood by-products and residues ^a	1.1.2 Forest, plantation and other virgin wood 1.2 By-products and residues from wood processing industry 1.3.1 Chemically untreated used wood	1.1 Forest, plantation and other virgin wood 1.2 By-products and residues from wood processing industry 1.3.1 Chemically untreated used wood	1.1 Forest, plantation and other virgin wood 1.2 By-products and residues from wood processing industry 1.3.1 Chemically untreated used wood	1.1 Forest, plantation and other virgin wood 1.2 By-products and residues from wood processing industry 1.3.1 Chemically untreated used wood	1.1 Forest, plantation and other virgin wood 1.2 By-products and residues from wood processing industry 1.3.1 Chemically untreated used wood
Diameter, D ^a and Length L ^b , ISO 17829	mm	D06, 6 ± 1; D08, 8 ± 1; 3,15 ≤ L ≤ 40	D06 to D25, D ± 1; 3,15 ≤ L ≤ 40 (from D06 to D10) 3,15 ≤ L ≤ 50 (from D12 to D25) M08 ≤ 8 M10 ≤ 10	D06 to D25, D ± 1; 3,15 ≤ L ≤ 40 (from D06 to D10) 3,15 ≤ L ≤ 50 (from D12 to D25) M08 ≤ 8 M10 ≤ 10	D06 to D25, D ± 1; 3,15 ≤ L ≤ 40 (from D06 to D10) 3,15 ≤ L ≤ 50 (from D12 to D25) M08 ≤ 8 M10 ≤ 10	D06 to D25, D ± 1; 3,15 ≤ L ≤ 40 (from D06 to D10) 3,15 ≤ L ≤ 50 (from D12 to D25) M08 ≤ 8 M10 ≤ 10	D06 to D25, D ± 1; 3,15 ≤ L ≤ 40 (from D06 to D10) 3,15 ≤ L ≤ 50 (from D12 to D25) M08 ≤ 8 M10 ≤ 10
In accordance with Figure 1							
Moisture, M ^c , ISO 18134-1, ISO 18134-2	w-% as received wet basis	A1.2 ≤ 1,2 DU97.5 ≥ 97,5	A3.0 ≤ 3,0 DU96.0 ≥ 96,0	A5.0 ≤ 5,0 DU95.0 ≥ 95,0	A5.0 ≤ 5,0 DU95.0 ≥ 95,0	A5.0 ≤ 5,0 DU95.0 ≥ 95,0	A5.0 ≤ 5,0 DU95.0 ≥ 95,0
Ash, A, ISO 18122	w-% dry	F2.0 ≤ 2,0	F1.0 ≤ 1,0	F4.0 ≤ 4,0	F2.0 ≤ 2,0	F6.0 ≤ 6,0	F3.0 ≤ 3,0
Mechanical durability, DU, ISO 17831-1	w-% as received	Type and amount to be stated	Type and amount to be stated	Type and amount to be stated	Type and amount to be stated	Type and amount to be stated	Type and amount to be stated
Fines, F ^d , ISO 18846	w-% dry	Q _a ≥ 21,0 Q _a < 5,8	Q _a ≥ 21,0 Q _a < 5,8	Q _a ≥ 21,0 Q _a < 5,8	Q _a ≥ 21,0 Q _a < 5,8	Q _a ≥ 21,0 Q _a < 5,8	Q _a ≥ 21,0 Q _a < 5,8
Additives ^e		Value to be stated	Value to be stated	Value to be stated	Value to be stated	Value to be stated	Value to be stated
Net calorific value, Q _{net} , ISO 18125	MJ/kg or kWh/kg as received	Value to be stated	Value to be stated	Value to be stated	Value to be stated	Value to be stated	Value to be stated
Bulk density, BD, ISO 17828	kg/m ³ as received	Value to be stated	Value to be stated	Value to be stated	Value to be stated	Value to be stated	Value to be stated
Carbon, C, ISO 16948	w-% dry	N0.4 ≤ 0,4	N0.4 ≤ 0,4	N0.4 ≤ 0,4	N0.4 ≤ 0,4	N0.4 ≤ 0,4	N0.4 ≤ 0,4
Nitrogen, N, ISO 16948	w-% dry	S0.04 ≤ 0,04	S0.04 ≤ 0,04	S0.05 ≤ 0,05	S0.05 ≤ 0,05	S0.1 ≤ 0,1	S0.1 ≤ 0,1
Sulfur, S, ISO 16994	w-% dry	Cl0.03 ≤ 0,03	Cl0.03 ≤ 0,03	Cl0.05 ≤ 0,05	Cl0.05 ≤ 0,05	Cl0.1 ≤ 0,1	Cl0.1 ≤ 0,1
Chlorine, Cl, ISO 16968	w-% dry	≤ 1	≤ 1	≤ 2	≤ 2	≤ 2	≤ 2
Arsenic, As, ISO 16968	mg/kg dry	≤ 10	≤ 10	≤ 15	≤ 15	≤ 20	≤ 20
Cadmium, Cd, ISO 16968	mg/kg dry	≤ 10	≤ 10	≤ 20	≤ 20	≤ 20	≤ 20
Chromium, Cr, ISO 16968	mg/kg dry	≤ 10	≤ 10	≤ 20	≤ 20	≤ 20	≤ 20
Copper, Cu, ISO 16968	mg/kg dry	≤ 10	≤ 10	≤ 20	≤ 20	≤ 20	≤ 20
Lead, Pb, ISO 16968	mg/kg dry	≤ 10	≤ 10	≤ 20	≤ 20	≤ 20	≤ 20
Mercury, Hg, ISO 16968	mg/kg dry	≤ 10	≤ 10	≤ 20	≤ 20	≤ 20	≤ 20
Nickel, Ni, ISO 16968	mg/kg dry	≤ 10	≤ 10	≤ 20	≤ 20	≤ 20	≤ 20
Zinc, Zn, ISO 16968	mg/kg dry	≤ 10	≤ 10	≤ 20	≤ 20	≤ 20	≤ 20
Volatile matter, VM, ISO 18123	w-% dry	Value to be stated	Value to be stated	Value to be stated	Value to be stated	Value to be stated	Value to be stated
Informative							
Ash melting behaviour ^f , ISO 21404	°C	Should be stated	Should be stated	Should be stated	Should be stated	Should be stated	Should be stated

^a Selected size of pellets to be stated. Examples D06, D08, D10, D25.
^b For D06 to D10 the amount of pellets longer than 40 mm can be 1 w-%. Maximum length shall be ≤ 45 mm.
^c At the point of delivery.
^d At the point of delivery. Fines less than 3,15 mm are screened by hand according standard ISO 18846.
^e At the point of delivery. Fines less than 3,15 mm are screened by hand according standard ISO 18846.
^f All characteristic temperatures (shrinkage starting temperature (SST), deformation temperature (DT), hemisphere temperature (HT) and flow temperature (FT)) in oxidizing conditions should be stated.

Energy Consumed along the chain

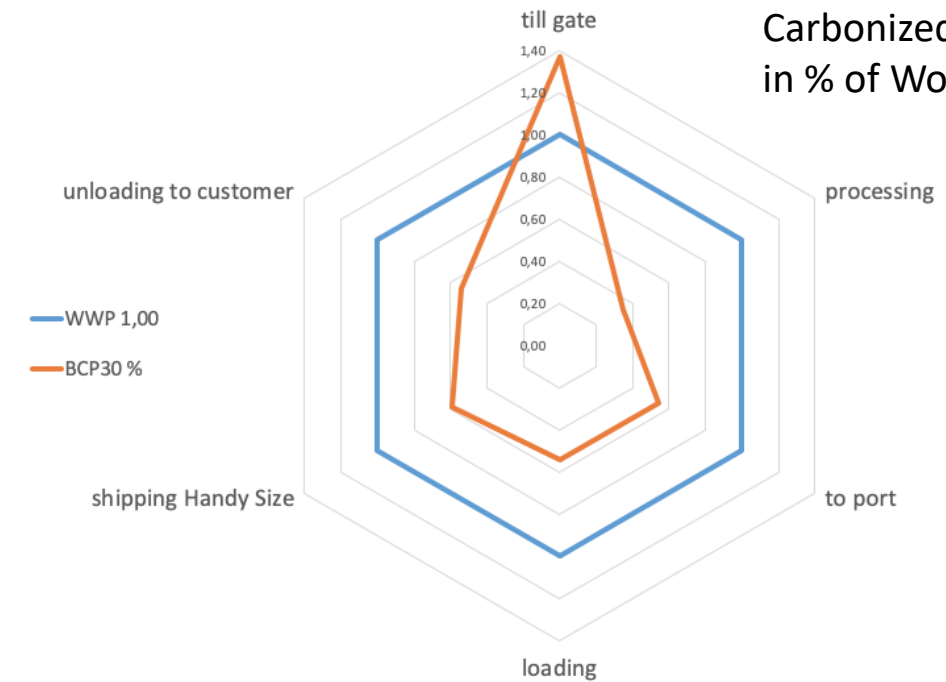
For Torrefied and Carbonized Biomass in % of Wood Pellet chain

Torrefied Biomass
in % of Wood Pellets



	WWP MJ/mt	TP MJ/mt		WWP MJ/GJ	TP MJ/GJ		WWP 1,00	TP %
till gate	627,75	758,47	till gate	35,75	34,17	till gate	1,00	0,96
processing	2.262,72	2.980,04	processing	128,86	134,24	processing	1,00	1,04
to port	36,24	36,24	to port	2,06	1,63	to port	1,00	0,79
loading	16,67	6,46	loading	0,95	0,75	loading	1,00	0,79
shipping HS	987,19	891,21	shipping HS	56,22	40,15	shipping HS	1,00	0,71
unloading to customer	86,07	86,07	unloading to customer	4,90	3,88	unloading to customer	1,00	0,79
total	4.016,64	4.758,48	total	228,74	214,81	total	1,00	0,94

Carbonized Biomass
in % of Wood Pellets



	WWP MJ/mt	BCP30 MJ/mt		WWP MJ/GJ	BCP30 MJ/GJ		WWP 1,00	BCP30 %
till gate	434,58	1.096,76	till gate	25,97	35,57	till gate	1,00	1,37
processing	2.181,83	1.391,45	processing	130,40	45,13	processing	1,00	0,35
to port	93,76	93,76	to port	5,60	3,04	to port	1,00	0,54
loading	16,67	6,46	loading	1,00	0,54	loading	1,00	0,54
shipping HS	892,70	967,09	shipping HS	53,35	31,37	shipping HS	1,00	0,59
unloading to customer	86,07	86,07	unloading to customer	5,14	2,79	unloading to customer	1,00	0,54
total	3.705,61	3.641,59	total	221,47	118,44	total	1,00	0,53

Conclusion

Thermal treatment does open agricultural biomass the door to the international biomass value chains by this increasing the amount of sustainable Biomass available substantially

Processing can take place in single or multiple steps

Depending on the degree of torrefaction value creation can be split flexibly between location of origin and international markets income

The reduced sustainability concerns will accelerate the uptake of agricultural biomass even more

It is high in time that feedstock owners get in touch with process technology owners to start creating value.

Thank you for paying attention

Contact



Michael Wild

Wild & Partner LLC

michael@wild.or.at



Rohrbacherstrasse 9

A-1130 Vienna

T +43 676 6117622

Skype: wildwien



IBTC – International Biomass Torrefaction Council

Place du Champ de Mars 2, 1050 Brussels

michael@wild.or.at; calderon@bioenergyeurope.org

<http://www.biomassstorrefaction.org>