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W&P

Torrefaction of Biomass- Status & Market Requirements, Supply Chain Efficiency Comparison

Michael Wild

Wild&Partner LLC, Vienna, Austria

IBTC, Brussels, Belgium

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Wild,M.; Torrefaction of Biomass- Status &Market Requirements, Supply Chain Efficency Comparison, presentation at ABLC, San Frabcisco, November 7th 2018

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Principle and Simplified Mass Balance

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INPUT: *Processing* *OUTPUT :*

Mass 100%
Energy 100%

reactor and process
temperature: ~ 300° C
residence time: ~ 30 min

Mass 70%
Energy 85%

Mass 30%
Energy 15%

predried biomass

mass	1200 kg/h
bulk density	200 kg/m³
dry mass	95 %
NCV	15-19MJ/kg

Syn-Gas to Combustion

mass	297 kg/h
GCV H_o	461 kJ/Nm³

torrified Biomass

mass	903 kg/h
bulk density	>650 kg/m³
dry mass	100 %
NCV	21-23MJ/kg

While processed, about 30% of its mass is extracted from the biomass paralleled by 15% energy content loss. This energy (the volatiles) is used to heat the ACB process.

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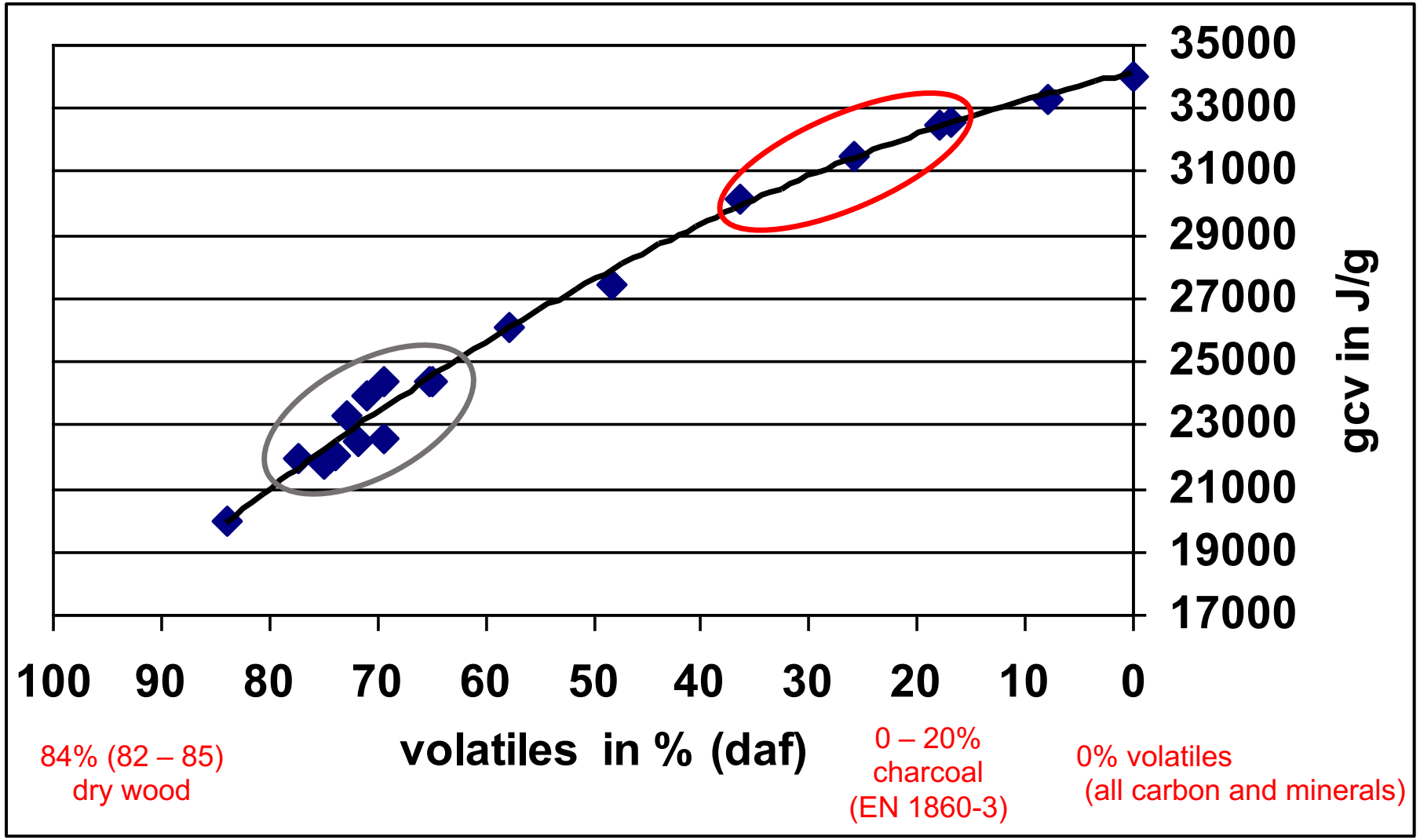
Carbonisation Reaction under Heat



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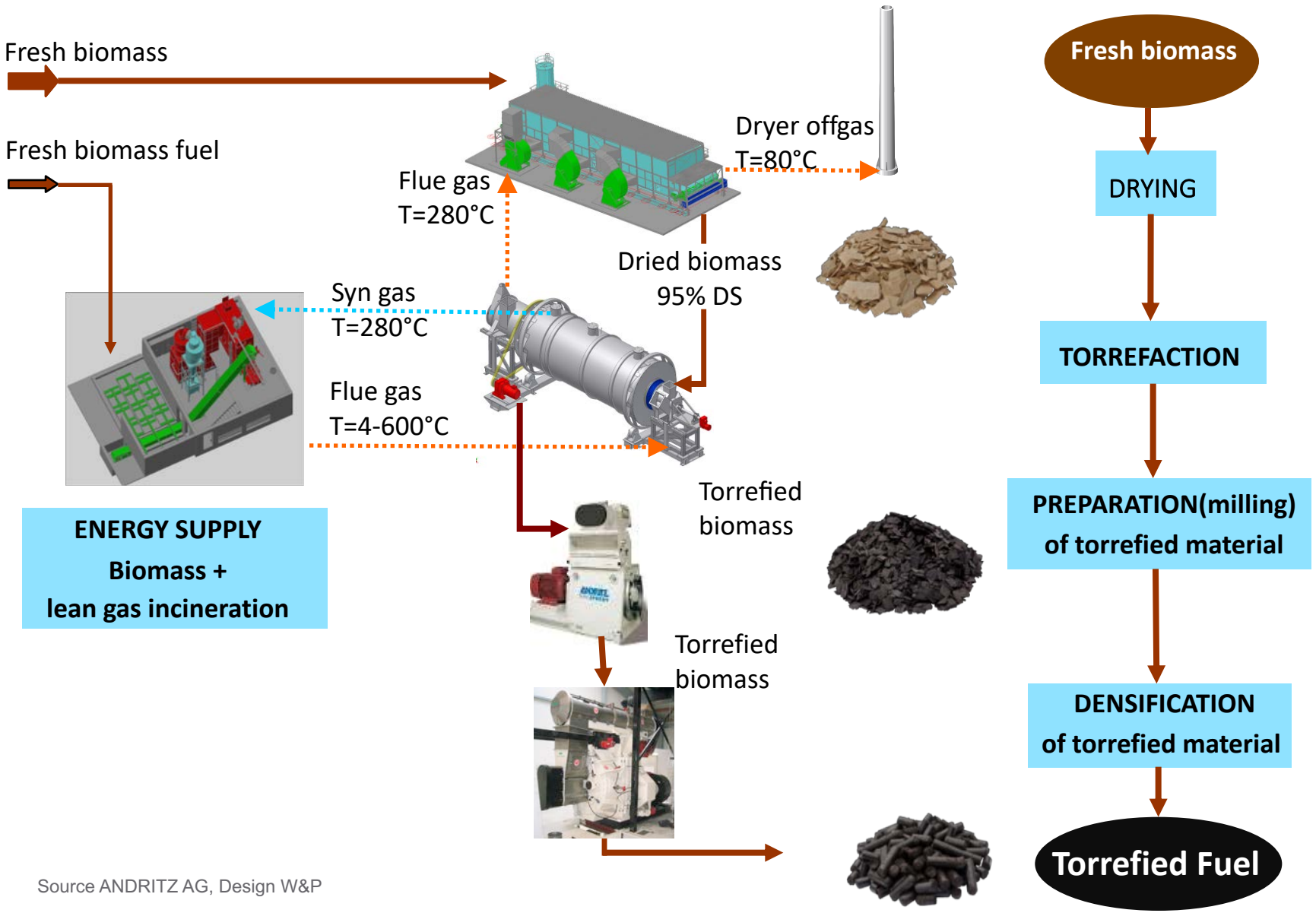
The torrefaction process (example ACB)



Source ANDRITZ AG, Design W&P

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Product Form Factors

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Torrefaction Implementation Indicator

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Torr-gas Handling and Utilisation		done
Continuous torrefaction		done
Predictability and consistency of product		for most feedstock
Densification		done
Feedstock flexibility		done
Plant Safety		done
Indoor storage		done
Outdoor storage		in optimisation
Standardisation of product		ISO TS 17225-8
Safety along supply chain		in progress
Trade Registrations and Permissions		in progress
Co-firing trials		done in EU
Co-firing burn tests		several done
Co-firing full scale		several done
Heat application trials		in progress
Further industrial applications trials		in progress
		MW 10 2018

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Understanding the Product

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- Torrefaction pre-processes and upgrades the biomass feedstock
- Number of technology Suppliers - FUNGIBLE PRODUCT
- Shapes of pellets or briquettes for storage and transport
- Well defined within ISO Technical Specification ISO 17225-8
- Immediate biomass blending into coal stream in existing coal fired plants –grindability, water resistance, storability, morphology....
- Almost 0 biodegradation of product when stored
- Combusts cleaner, gasifies easier and cleaner
- NCV highest of all solid biofuels and best adjustable
- Reduces carbon footprint of supply chain substantially

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Quality – Standardisation

ISO 17225

Solid biofuels -Fuel specifications and classes

ISO TS 17225 - 8:

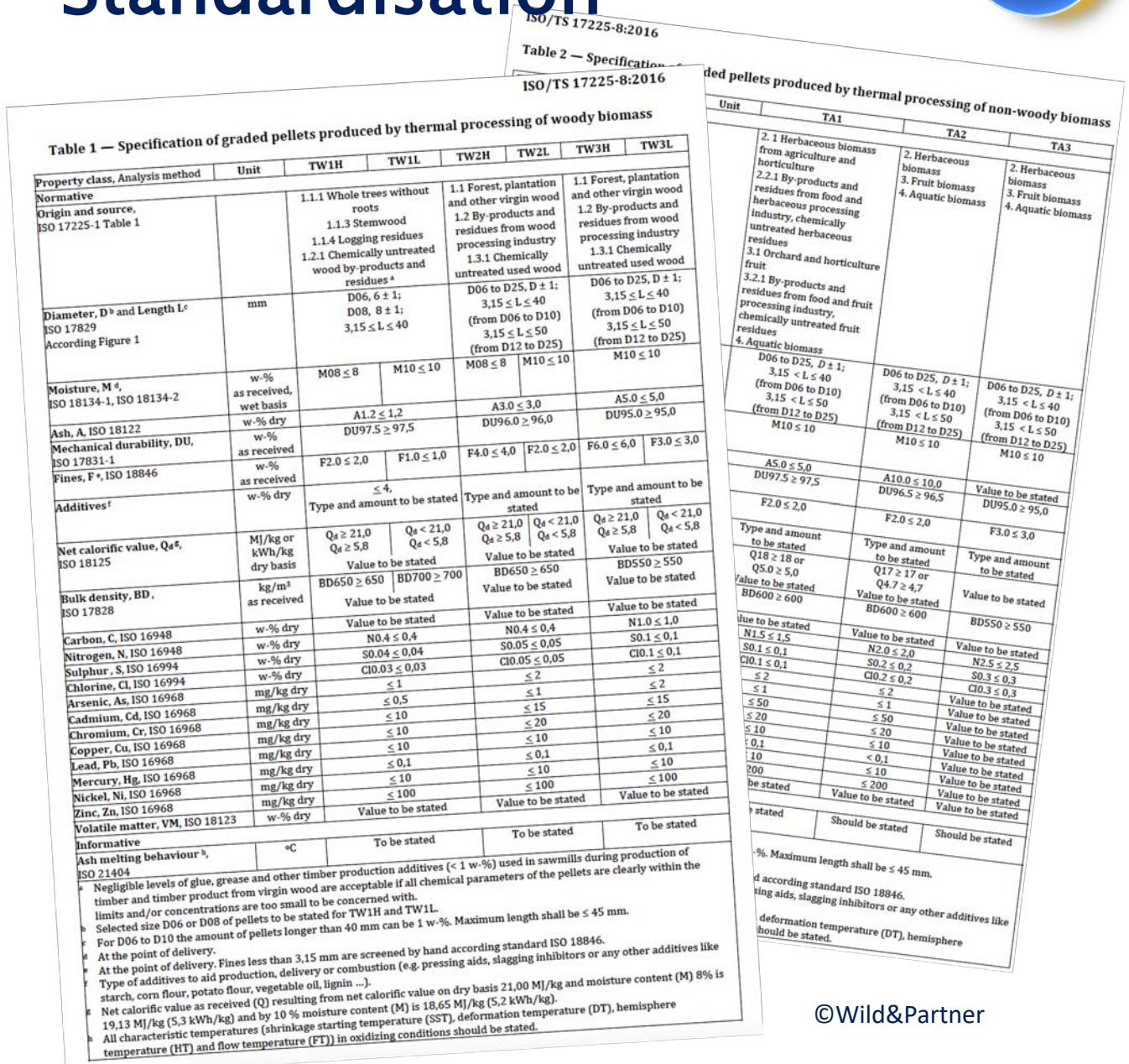
Part 8: Graded thermally treated and densified biomass fuels

Different Classes

Wood-Non Woody;NCV, Durability, Bulk Density, Volatile Matter etc.

Parameters in standard development:

Grindability
Water resistance



ISO/TS 17225-8:2016

Table 1 — 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 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 [b] and Length L [c] ISO 17829 According Figure 1	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)		D06 to D25, D ± 1; 3,15 ≤ L ≤ 40 (from D06 to D10) 3,15 ≤ L ≤ 50 (from D12 to D25)	
Moisture, M [d], ISO 18134-1, ISO 18134-2	w-% as received, wet basis	M08 ≤ 8	M10 ≤ 10	M08 ≤ 8	M10 ≤ 10	M10 ≤ 10	
Ash, A, ISO 18122	w-% dry	A1.2 ≤ 1,2		A3.0 ≤ 3,0		A5.0 ≤ 5,0	
Mechanical durability, DU, ISO 17831-1	w-% as received	DU97.5 ≥ 97,5		DU96.0 ≥ 96,0		DU95.0 ≥ 95,0	
Fines, F [e], ISO 18846	w-% as received	F2.0 ≤ 2,0	F1.0 ≤ 1,0	F4.0 ≤ 4,0	F2.0 ≤ 2,0	F6.0 ≤ 6,0	F3.0 ≤ 3,0
Additives [f]	w-% dry	≤ 4, Type and amount to be stated		Type and amount to be stated		Type and amount to be stated	
Net calorific value, Q_d [g], ISO 18125	MJ/kg or kWh/kg dry basis	Q_d ≥ 21,0 Q_d ≥ 5,8	Q_d < 21,0 Q_d < 5,8	Q_d ≥ 21,0 Q_d ≥ 5,8	Q_d < 21,0 Q_d < 5,8	Q_d ≥ 21,0 Q_d ≥ 5,8	Q_d < 21,0 Q_d < 5,8
		Value to be stated		Value to be stated		Value to be stated	
Bulk density, BD, ISO 17828	kg/m³ as received	BD650 ≥ 650	BD700 ≥ 700	BD650 ≥ 650		BD550 ≥ 550	
		Value to be stated		Value to be stated		Value to be stated	
Carbon, C, ISO 16948	w-% dry	Value to be stated		Value to be stated		Value to be stated	
Nitrogen, N, ISO 16948	w-% dry	N0.4 ≤ 0,4		N0.4 ≤ 0,4		N1.0 ≤ 1,0	
Sulphur , S, ISO 16994	w-% dry	S0.04 ≤ 0,04		S0.05 ≤ 0,05		S0.1 ≤ 0,1	
Chlorine, Cl, ISO 16994	w-% dry	Cl0.03 ≤ 0,03		Cl0.05 ≤ 0,05		Cl0.1 ≤ 0,1	
Arsenic, As, ISO 16968	mg/kg dry	≤ 1		≤ 2		≤ 2	
Cadmium, Cd, ISO 16968	mg/kg dry	≤ 0,5		≤ 1		≤ 2	
Chromium, Cr, ISO 16968	mg/kg dry	≤ 10		≤ 15		≤ 15	
Copper, Cu, ISO 16968	mg/kg dry	≤ 10		≤ 20		≤ 20	
Lead, Pb, ISO 16968	mg/kg dry	≤ 10		≤ 10		≤ 10	
Mercury, Hg, ISO 16968	mg/kg dry	≤ 0,1		≤ 0,1		≤ 0,1	
Nickel, Ni, ISO 16968	mg/kg dry	≤ 10		≤ 10		≤ 10	
Zinc, Zn, ISO 16968	mg/kg dry	≤ 100		≤ 100		≤ 100	
Volatile matter, VM, ISO 18123	w-% dry	Value to be stated		Value to be stated		Value to be stated	
Informative							
Ash melting behaviour [h], ISO 21404	°C	To be stated		To be stated		To be stated	

[a] Negligible levels of glue, grease and other timber production additives (< 1 w-%) used in sawmills during production of timber and timber product from virgin wood are acceptable if all chemical parameters of the pellets are clearly within the limits and/or concentrations are too small to be concerned with.
[b] Selected size D06 or D08 of pellets to be stated for TW1H and TW1L.
[c] For D06 to D10 the amount of pellets longer than 40 mm can be 1 w-%. Maximum length shall be ≤ 45 mm.
[d] At the point of delivery.
[e] At the point of delivery. Fines less than 3,15 mm are screened by hand according standard ISO 18846.
[f] Type of additives to aid production, delivery or combustion (e.g. pressing aids, slagging inhibitors or any other additives like starch, corn flour, potato flour, vegetable oil, lignin ...).
[g] Net calorific value as received (Q) resulting from net calorific value on dry basis 21,00 MJ/kg and moisture content (M) 8% is 19,13 MJ/kg (5,3 kWh/kg) and by 10 % moisture content (M) is 18,65 MJ/kg (5,2 kWh/kg).
[h] All characteristic temperatures (shrinkage starting temperature (SST), deformation temperature (DT), hemisphere temperature (HT) and flow temperature (FT)) in oxidizing conditions should be stated.

ISO/TS 17225-8:2016

Table 2 — Specification of graded pellets produced by thermal processing of non-woody biomass

Unit	TA1	TA2	TA3
	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
	D06 to D25, D ± 1; 3,15 < L ≤ 40 (from D06 to D10) 3,15 < L ≤ 50 (from D12 to D25)	D06 to D25, D ± 1; 3,15 < L ≤ 40 (from D06 to D10) 3,15 < L ≤ 50 (from D12 to D25)	D06 to D25, D ± 1; 3,15 < L ≤ 40 (from D06 to D10) 3,15 < L ≤ 50 (from D12 to D25)
	M10 ≤ 10	M10 ≤ 10	M10 ≤ 10
	A5.0 ≤ 5,0	A10.0 ≤ 10,0	Value to be stated
	DU97.5 ≥ 97,5	DU96.5 ≥ 96,5	DU95.0 ≥ 95,0
	F2.0 ≤ 2,0	F2.0 ≤ 2,0	F3.0 ≤ 3,0
	Type and amount to be stated	Type and amount to be stated	Type and amount to be stated
	Q18 ≥ 18 or Q5.0 ≥ 5,0 Value to be stated	Q17 ≥ 17 or Q4.7 ≥ 4,7 Value to be stated	Value to be stated
	BD600 ≥ 600	BD600 ≥ 600	BD550 ≥ 550
	ue to be stated	Value to be stated	Value to be stated
	N1.5 ≤ 1,5	N2.0 ≤ 2,0	N2.5 ≤ 2,5
	S0.1 ≤ 0,1	S0.2 ≤ 0,2	S0.3 ≤ 0,3
	Cl0.1 ≤ 0,1	Cl0.2 ≤ 0,2	Cl0.3 ≤ 0,3
	≤ 2	≤ 2	Value to be stated
	≤ 1	≤ 1	Value to be stated
	≤ 50	≤ 50	Value to be stated
	≤ 20	≤ 20	Value to be stated
	≤ 10	≤ 10	Value to be stated
	0,1	< 0,1	Value to be stated
	10	≤ 10	Value to be stated
	200	≤ 200	Value to be stated
	be stated	Value to be stated	Value to be stated
	stated	Should be stated	Should be stated

-%. Maximum length shall be ≤ 45 mm.
d according standard ISO 18846.
ing aids, slagging inhibitors or any other additives like
deformation temperature (DT), hemisphere
hould be stated.

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Products and supply chains compared (LLC)

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Technically in all parameters superior to Wood Pellets

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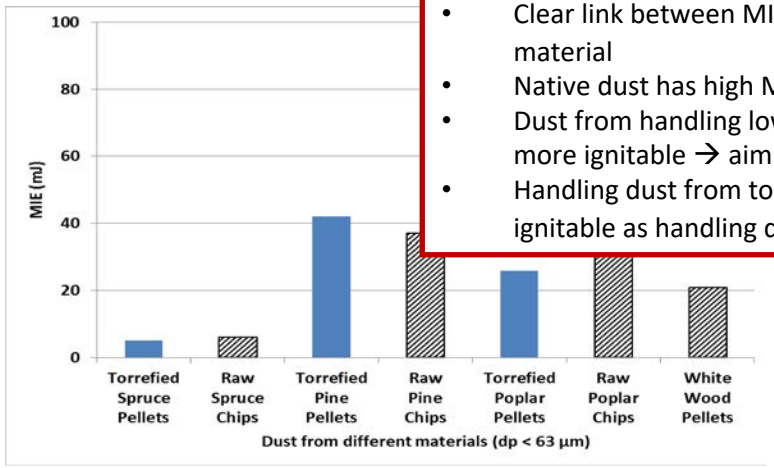
Minimum Ignition Energy Pulverised
torrefied pellets vs. pulverised raw biomass chips



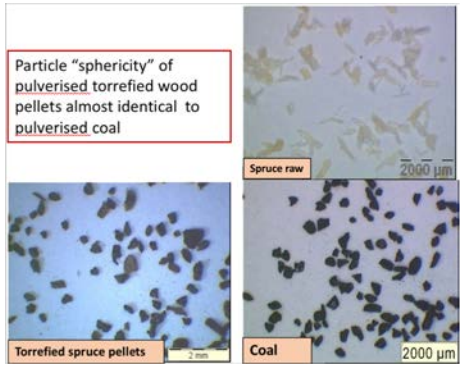
- Clear link between MIE torrefied pellets with MIE raw material
- Native dust has high MIE's
- Dust from handling low durability pellets (< 93%) is more ignitable → aim for pellet durability ≥ 95%
- Handling dust from torrefied wood pellets is equally ignitable as handling dusts from white wood pellets

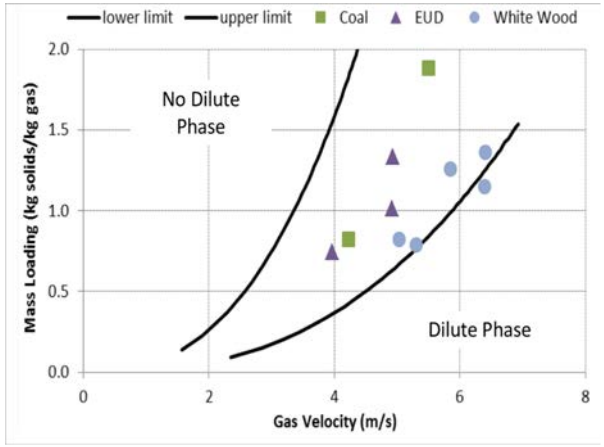
Biological Degradation

Pellets stored 20 days at 20° C at 95% relative humidity

- Dry matter losses significantly higher for white wood pellets, compared with torrefied wood pellets
- Also after uncovered outdoor exposure for 3 months

Fuel Morphology, pneumatic transport





Water Resistance

Full water resistance achieved by several producers with or without binders resp. coating

Source: Carbo et al. "Fuel pre-processing, pre-treatment and storage for co-firing of biomass and coal" in "Fuel Flexible Energy Generation" ed. J. Oakey, 2015

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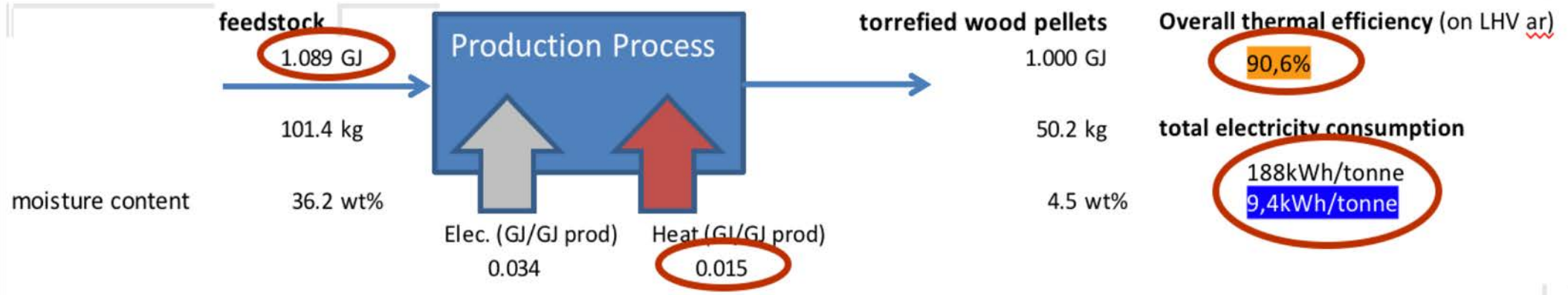
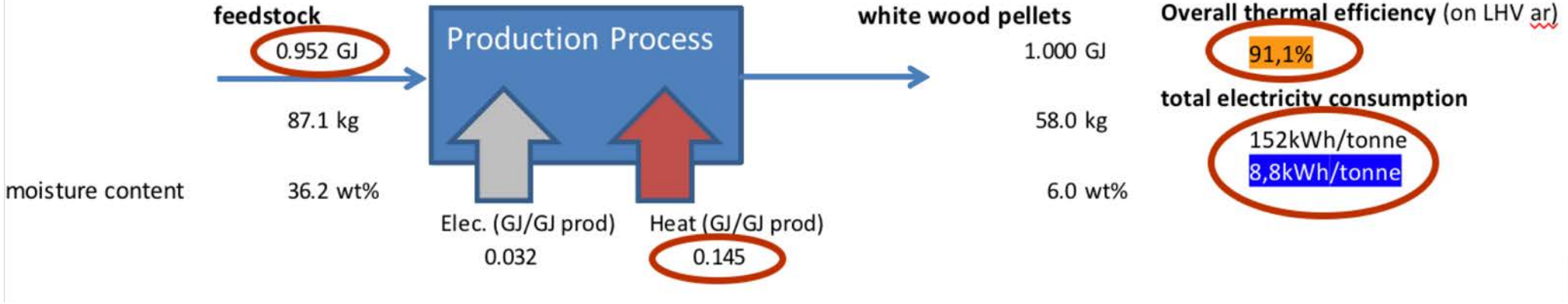
Energy Balance Comparison

Study carried out by ECN, UMEA university and CENER

Torrefaction Pellets (from aggregated averages survey entries)



White Pellets (from average data compilation)



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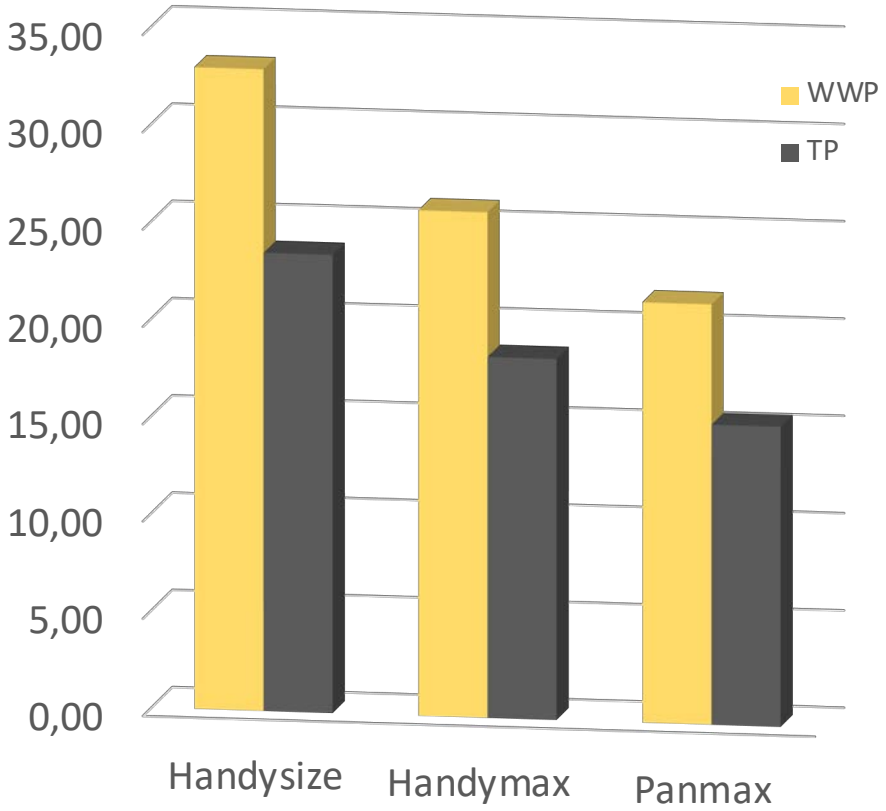
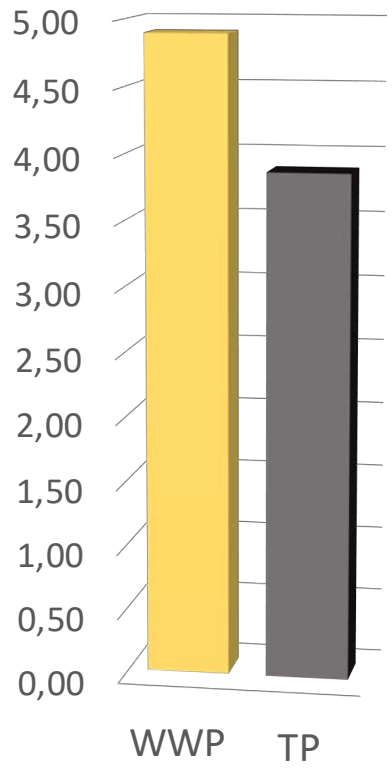
Advantages in Logistics

WWP versus TP: Energy consumed in shipping in MJ/GJ shipped



Energy Consumption from vessel to plant stockyard in MJ/GJ



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WWP versus ca. 21/30 GJ TP - Energy consumed in MJ per GJ energy delivered to Consumer stockpile

WWP MJ/GJ

TP MJ/GJ

TW MJ/GJ if briquetted

250
200
150
100
50
0

till gate
processing
to port
loading
shipping HS
unloading to customer
total

21
30

Source and Copyright: W&P

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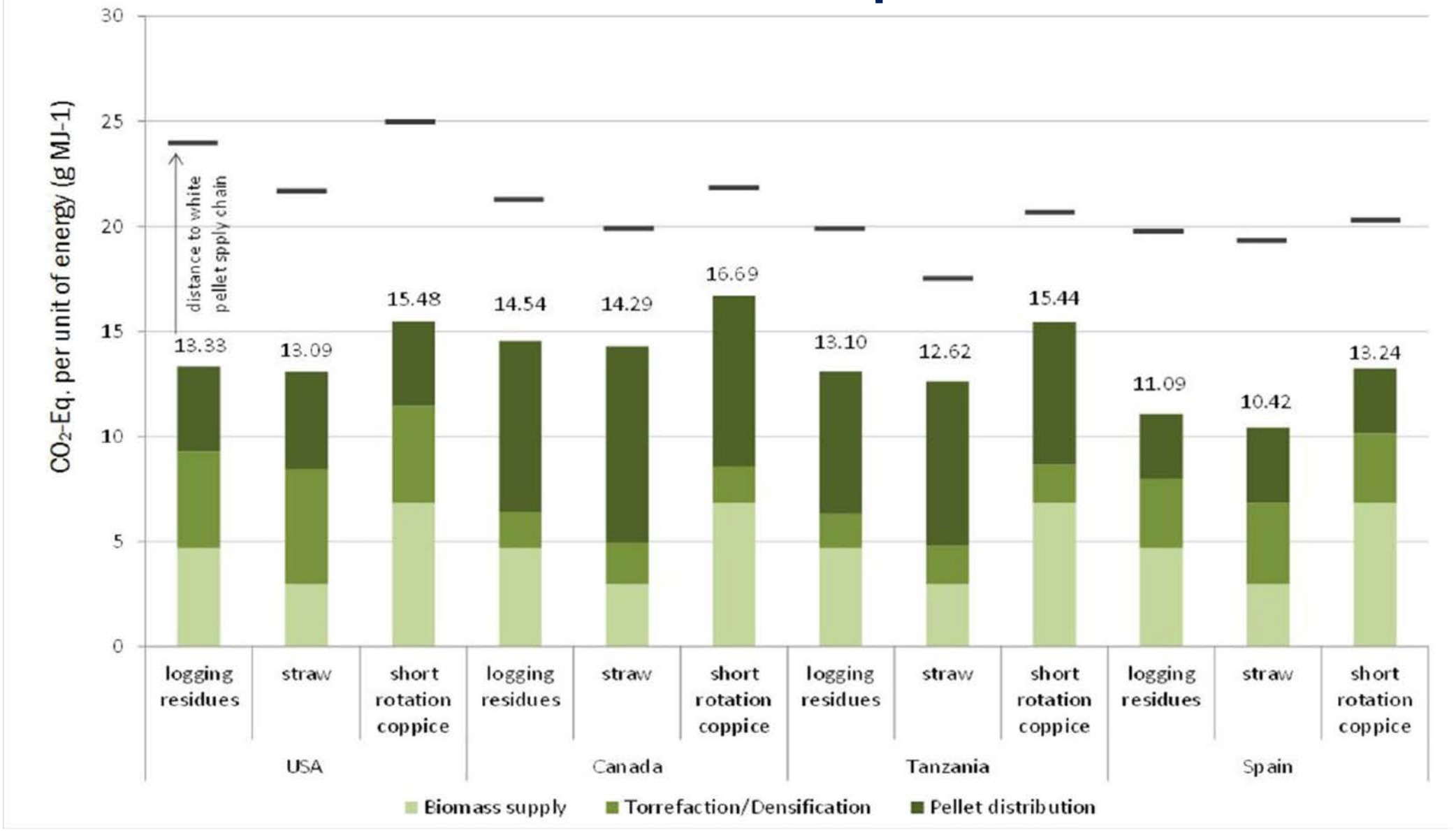
GHG Comparison



Source: D. Thrän, DBFZ

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Positive Experience in co-firing

- Confirmation of superior characteristics of torrefied pellets
- No adverse effect on milling and combustion detected
- Low dust formation
- Torrefied biomass can replace coal in power plants

Topell Energy, RWE The energy to lead, NUON, VATTENFALL, GDF SUEZ, ECN

DONG Studstrup-3 experience

- Two units with total capacity of 714 MW_e and 986 MW_{th}
- Dedicated milling on MPS roller mill adapted for either coal or white pellets
- 200 tons of Andritz/ECN torrefied spruce pellets during 8 hours trial
- Co-firing share: 33 wt%
- Observations:
  - No dust formation during unloading
  - Sufficiently high durability; no issues with dust formation in chain conveyors
  - Normal Minimum Ignition Energy (MIE)
- ECN conducted lab-scale characterisation of pellets

Source: ECN

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Feedstock Flexibility

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

By this Torrefaction is the processing that does open up the energy market for Agricultural by products, grassy crops and other unused biomasses with unacceptable high Chlorine content

The effect is a significant: reduction in the feedstock costs
Side effect: no sustainability concerns

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Diversity of Products

Volume Product: Fuel for Pulverized Coal Power Plants

Value Products:
- Fuel for Heating
- Fuel for Process Energy Needs
- Feedstock for Gasification
- Soil enhancer
- Carbon provider for Plastics industry
- Activated Carbon
- Products for new (niche) markets

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Messages to take home

- Integrated Torrefaction Process Technology mature, available, happening
- Feedstock Flexibility
- Fungible Standard (ISO) Product with adjustment possibilities
- Superior behaviour to all other solid biomasses
- Lowest CO2 footprint
- Ships like coal, stores like coal, mills like coal and combusts like coals
- Reduced sensitivity to changes in cost factors along the supply chain
- Torrefaction is happening in industrial plants
- Product supply available: Project pipelines in Asia and Globally

Not many reasons using the intermediate products from wood, go for the final products and capitalize on the advantages

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.biomasstorrefaction.org