INTERNATIONAL BIOMASS TORREFACTION COUNCIL
AN AEBIOM NETWORK

W&P

Showcase pretreatment: impact of torrefaction pretreatment on costs delivered CIF in Japan and on supply chain GHG emissions

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Sept. 2018

The Contents

- The role of logistics in Biomass Supply Chains
- What is Torrefaction and/or Carbonization
- Comparison along the supply chain
- Stand alone versus co-located production
- Understanding torrefied products
- Characteristics in handling and consumption
- Today´s Suppliers

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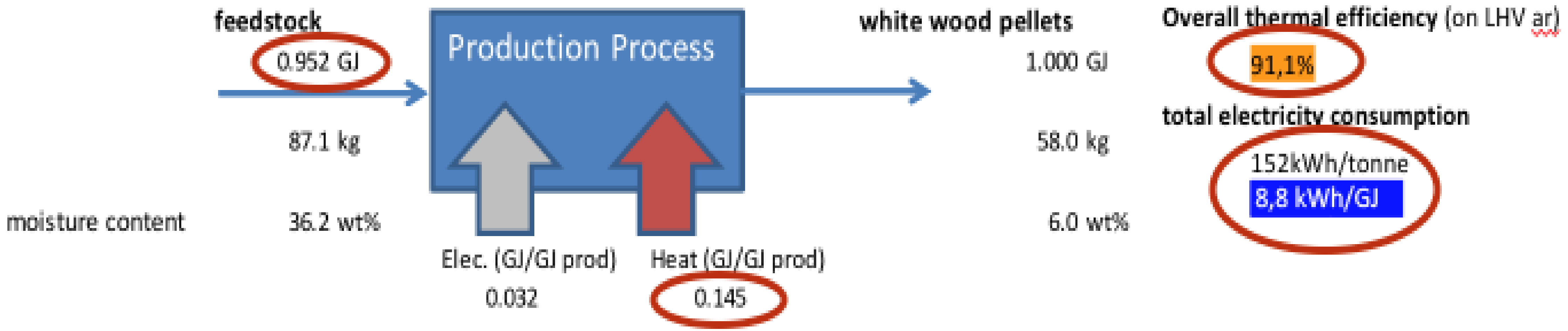
Energy Balance Processing

Study carried out by ECN, UMEA university and CENER

White Pellets (from average data compilation)



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Logistics in WP Full Supply Chain

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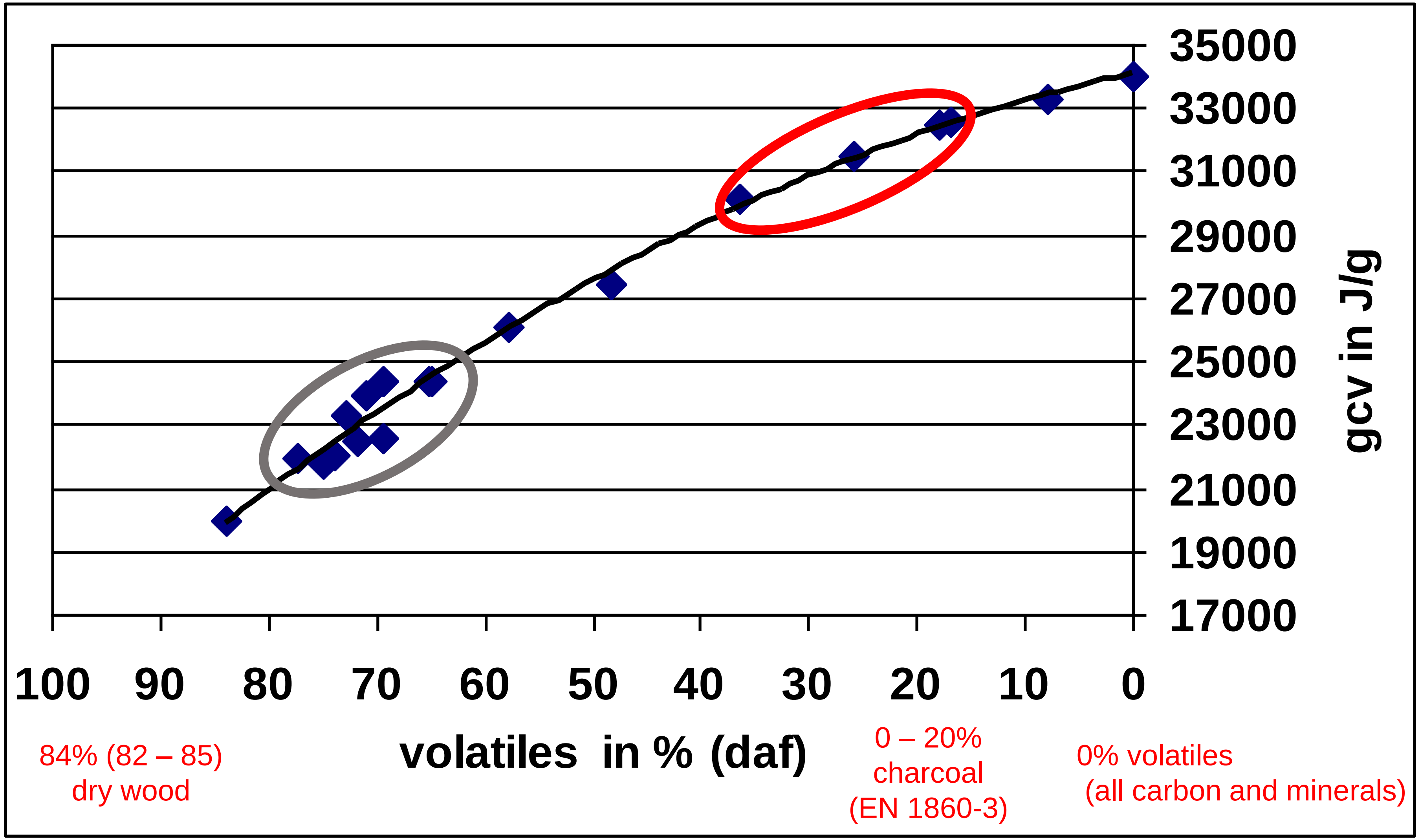
Cost item		Cost in percent of price at end user	of which allocated to logistics
Feed stock		1 to 25	
	if mill residues		1
	if road side or standing		10 to 25
Mill		8 to 15	
Finance		6 to 10	
Transport to port		5 to 10	5 to 10
Storage, load/unload		5 to 12	5 to 12
Ocean shipping		12 to 20	12 to 20
Transport to end user		2 to 10	2 to 10
Risk and profit		20+	
		59 to 122*	34 to 77*
* in these cases, the projects would not be viable			

Products and supply chains compared (LLC)

White Wood Pellets

Torrefied/Carbonized Wood Pellets

Carbonisation Reaction under Heat



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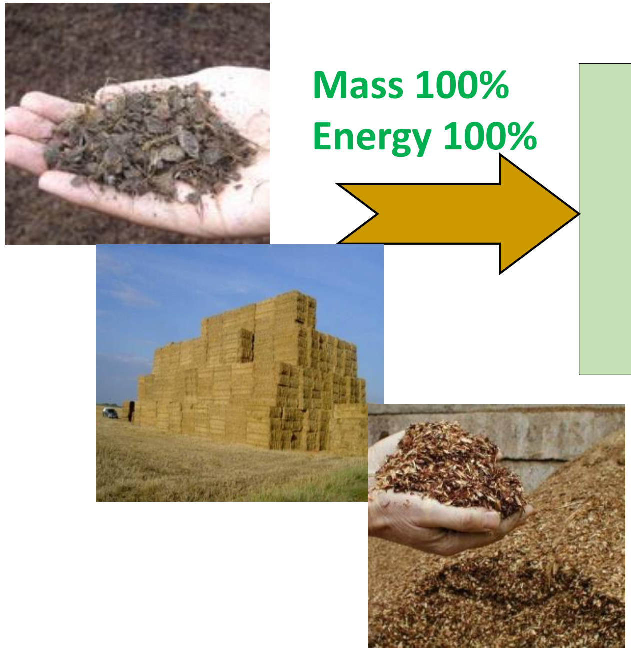
Principle and Simplified Mass Balance Torrefaction/light Carbonization

INPUT:



Mass 100%
Energy 100%

Processing

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

Mass 30%
Energy 15%

OUTPUT :

Mass 70%
Energy 85%

Energy Density

		Black Coal	Wood Pellets	Steam Exploded Pellets	Torrefied Pellets	Carbonised Pellets
Energy Content	GJ/tonne	25,13	17,5	19	21	30
Bulk Density	kg/m^3	800	650	650	700	700
Energy Density	GJ/m^3	20,10	11,38	12,35	14,70	20,70

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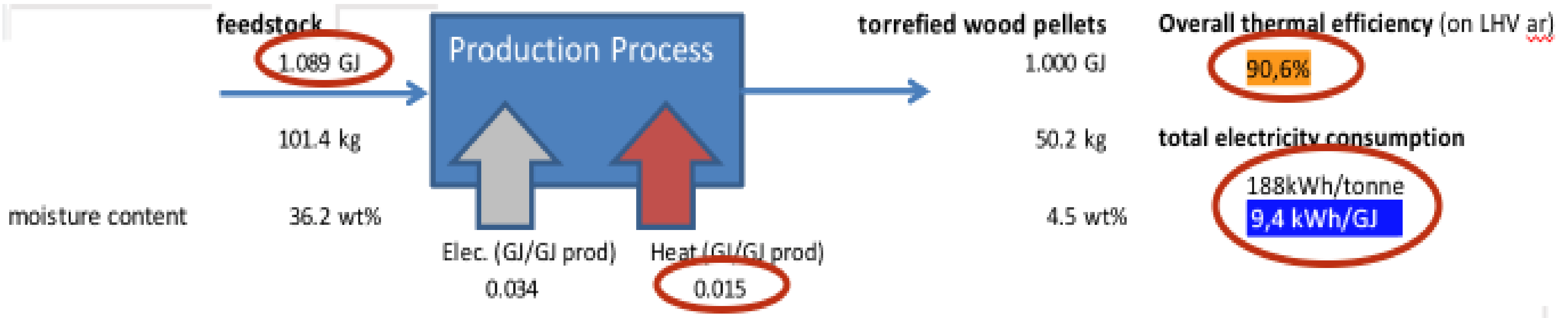
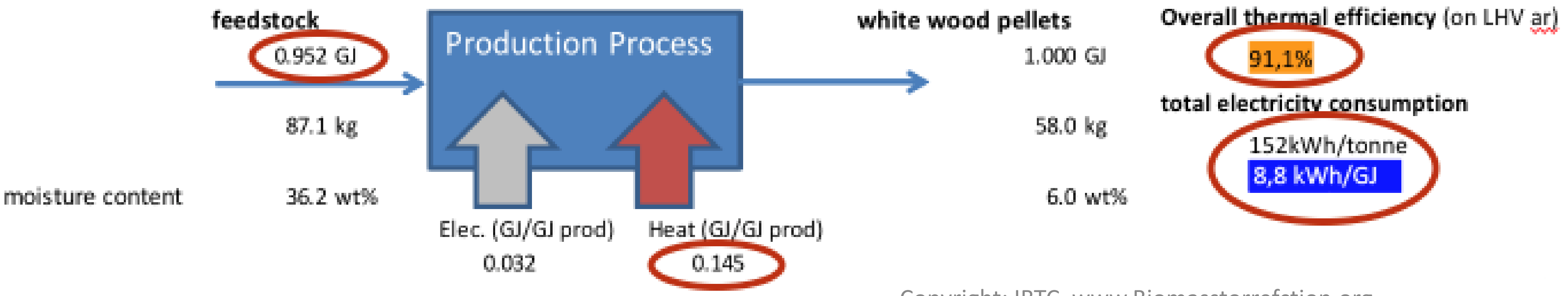
Energy Balance Comparison

Study carried out by ECN, UMEA university and CENER

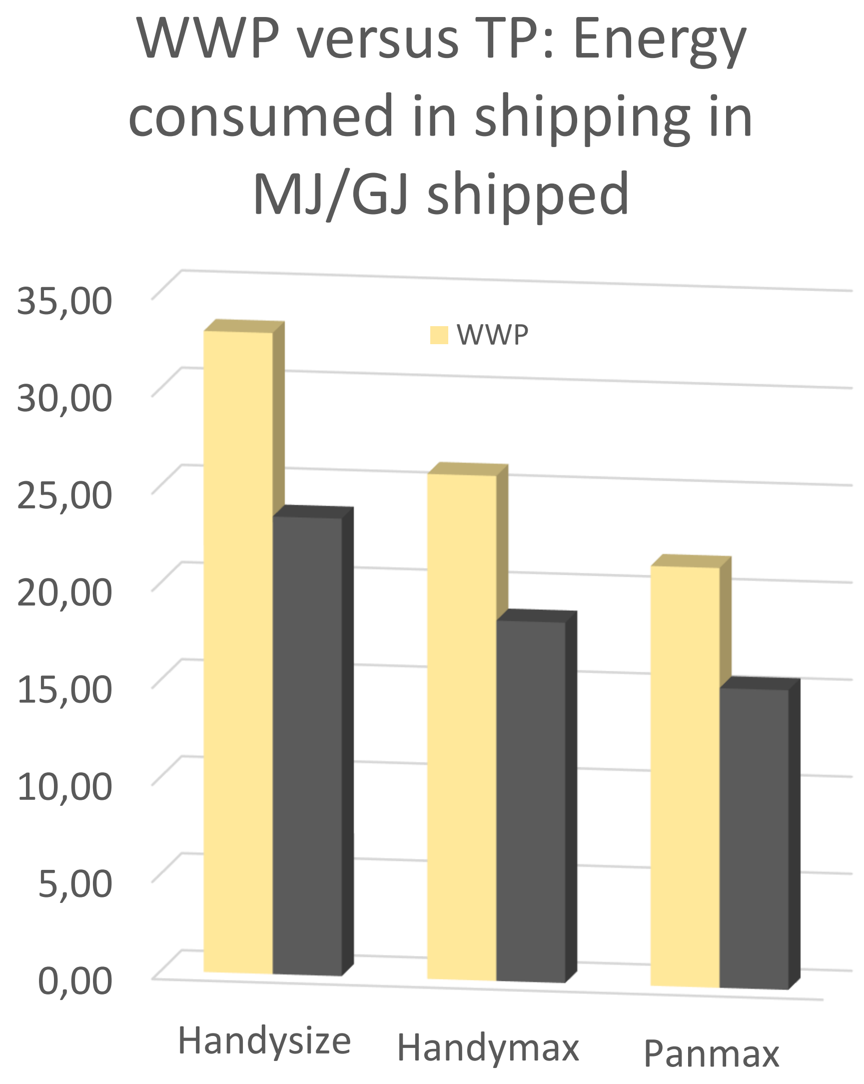
Torrefaction Pellets (from aggregated averages survey entries)

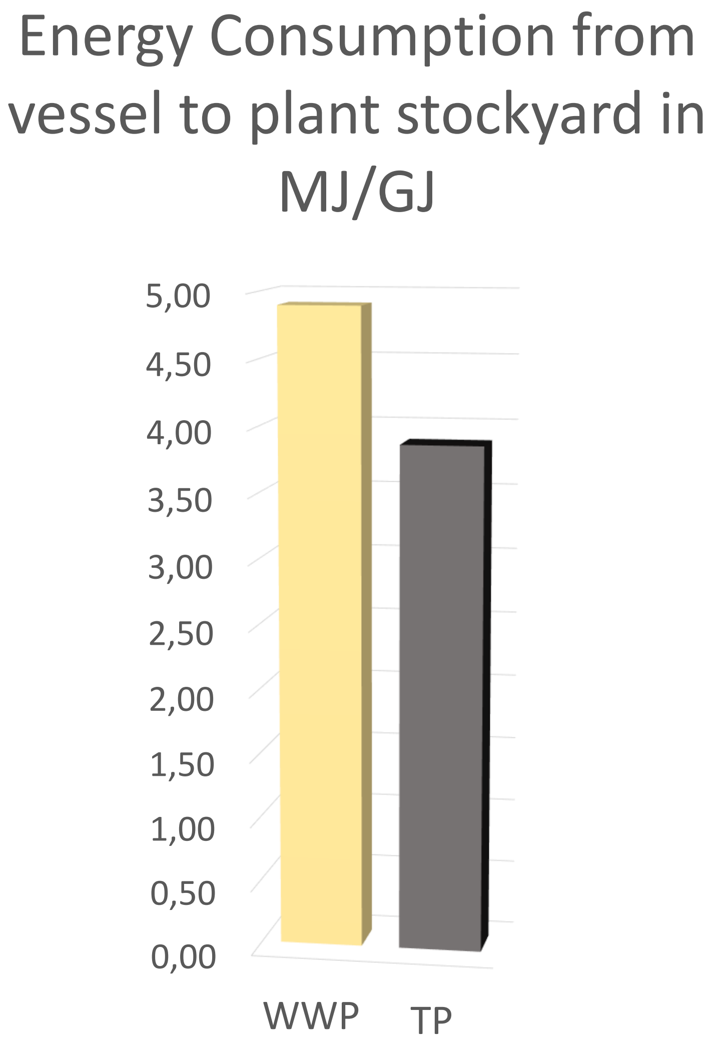


White Pellets (from average data compilation)

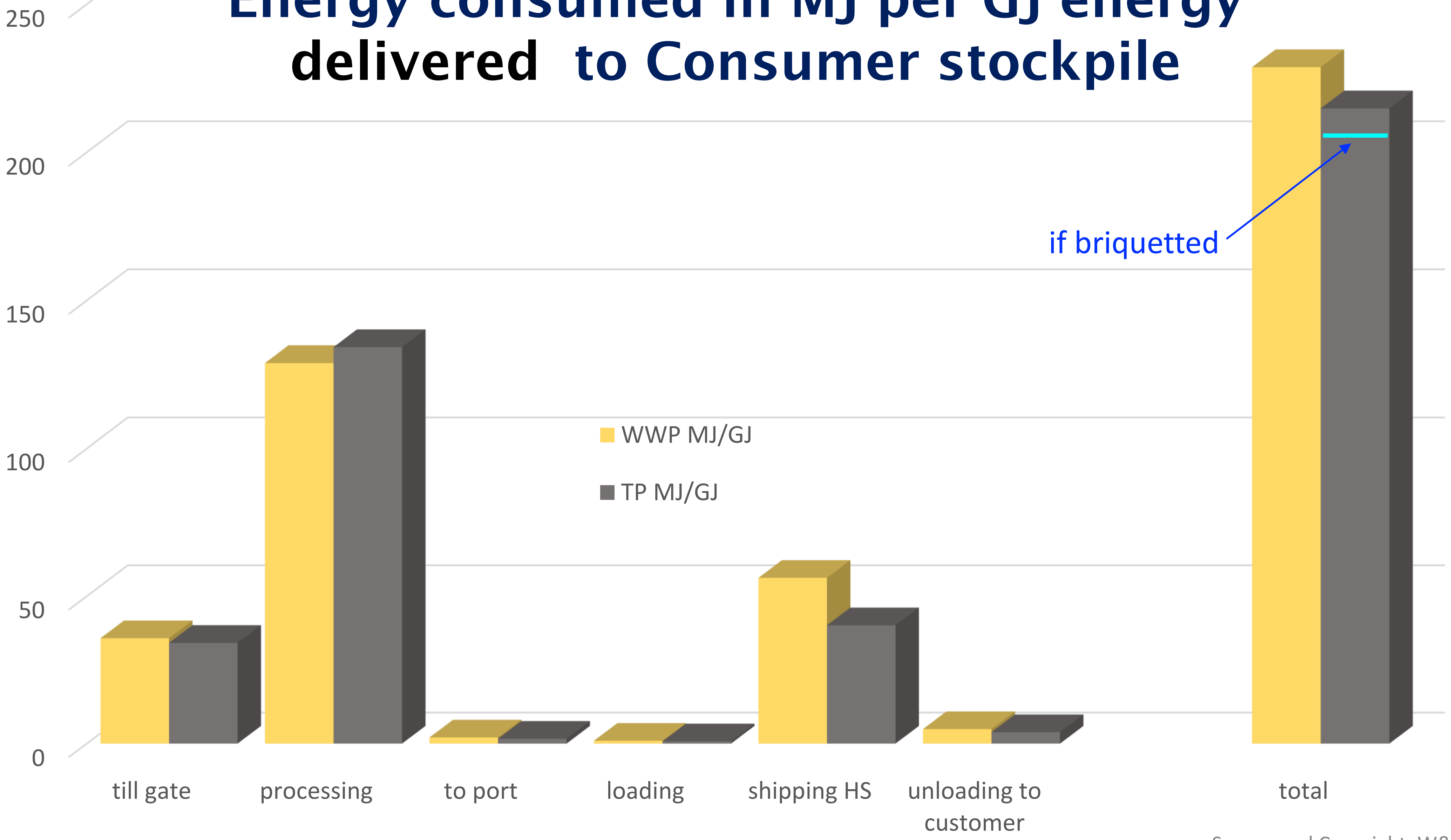


Advantages in Logistics example Indonesia–Japan





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



Source and Copyright: W&P

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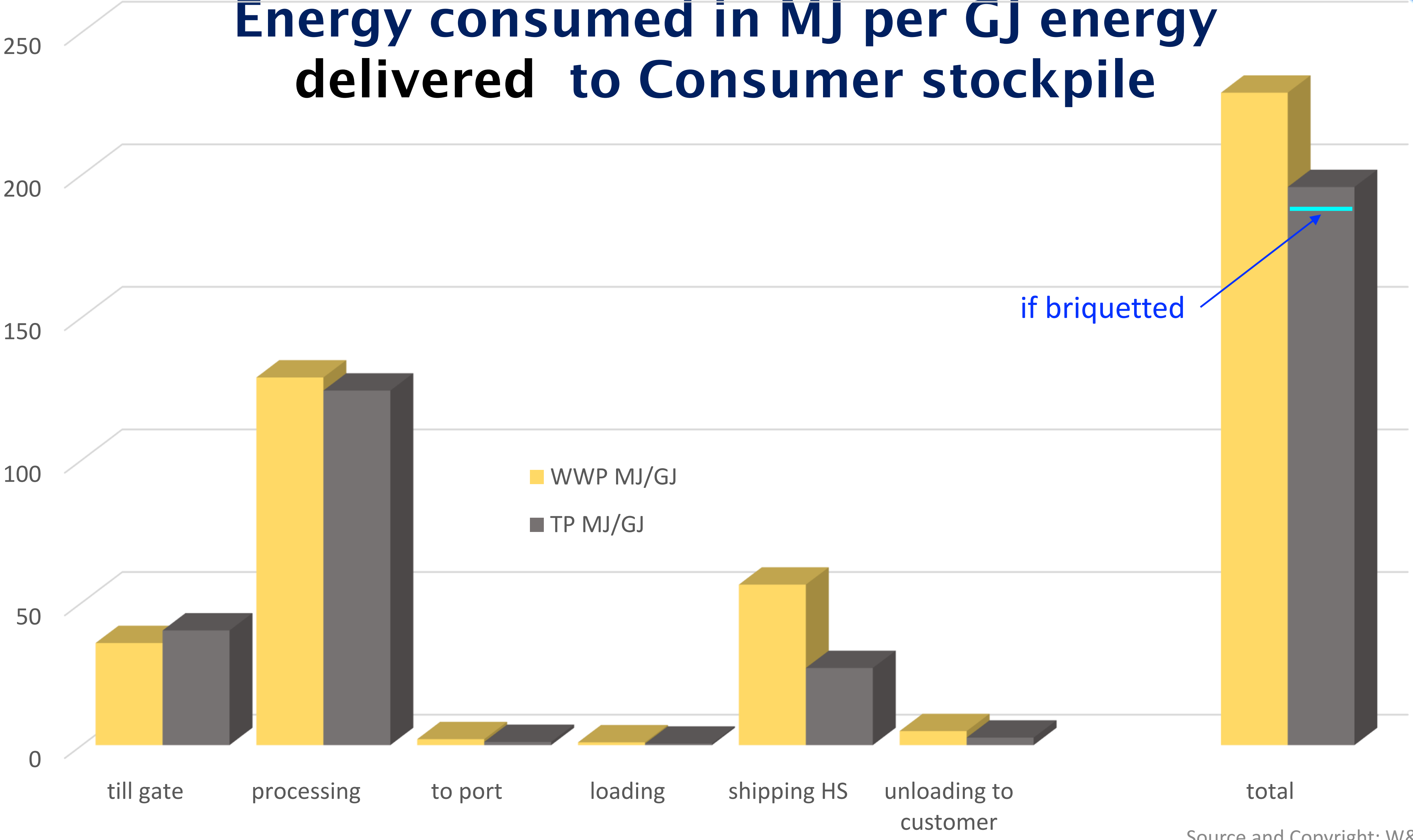
WWP versus ca. 30GJ TP - Energy consumed in MJ per GJ energy delivered to Consumer stockpile



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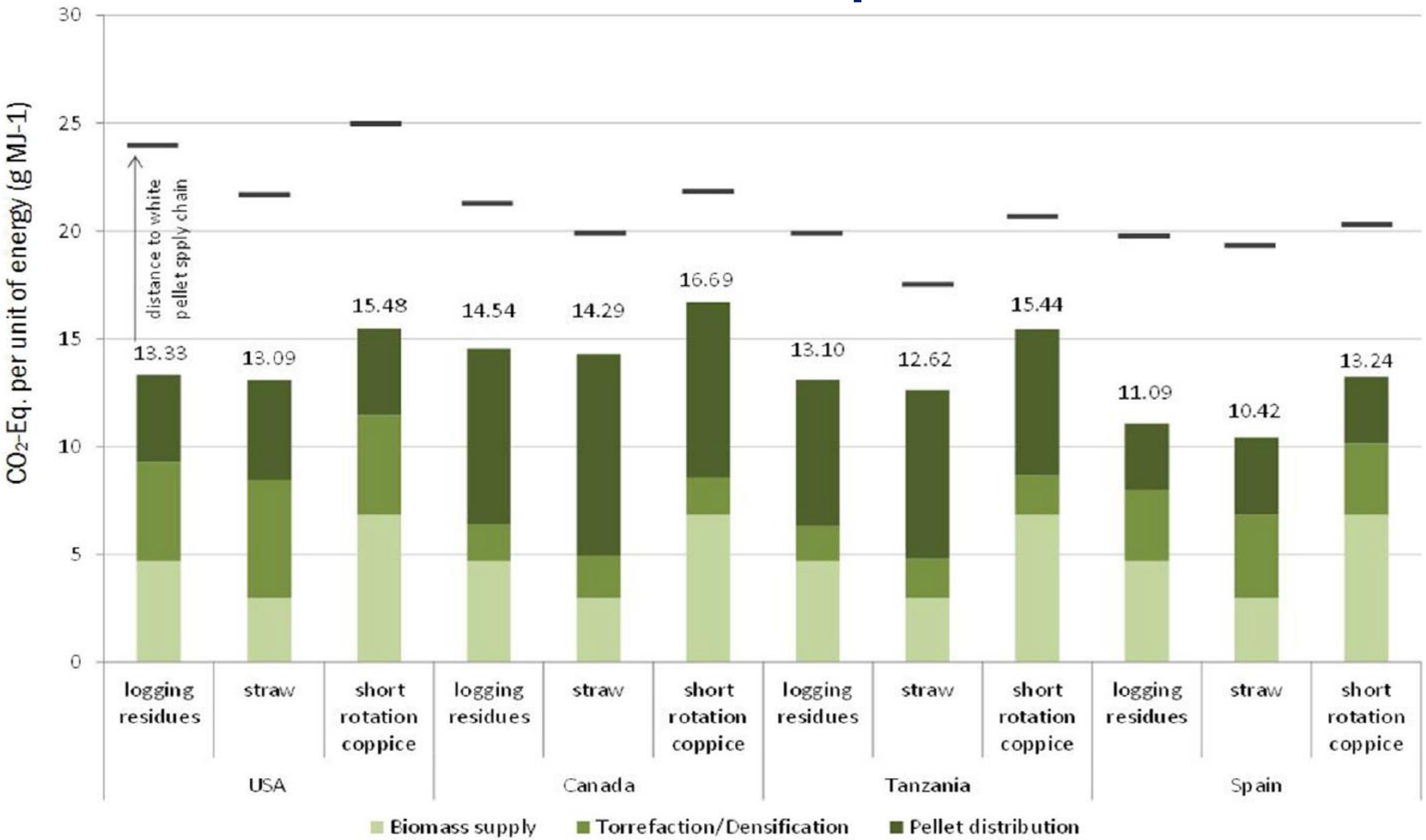
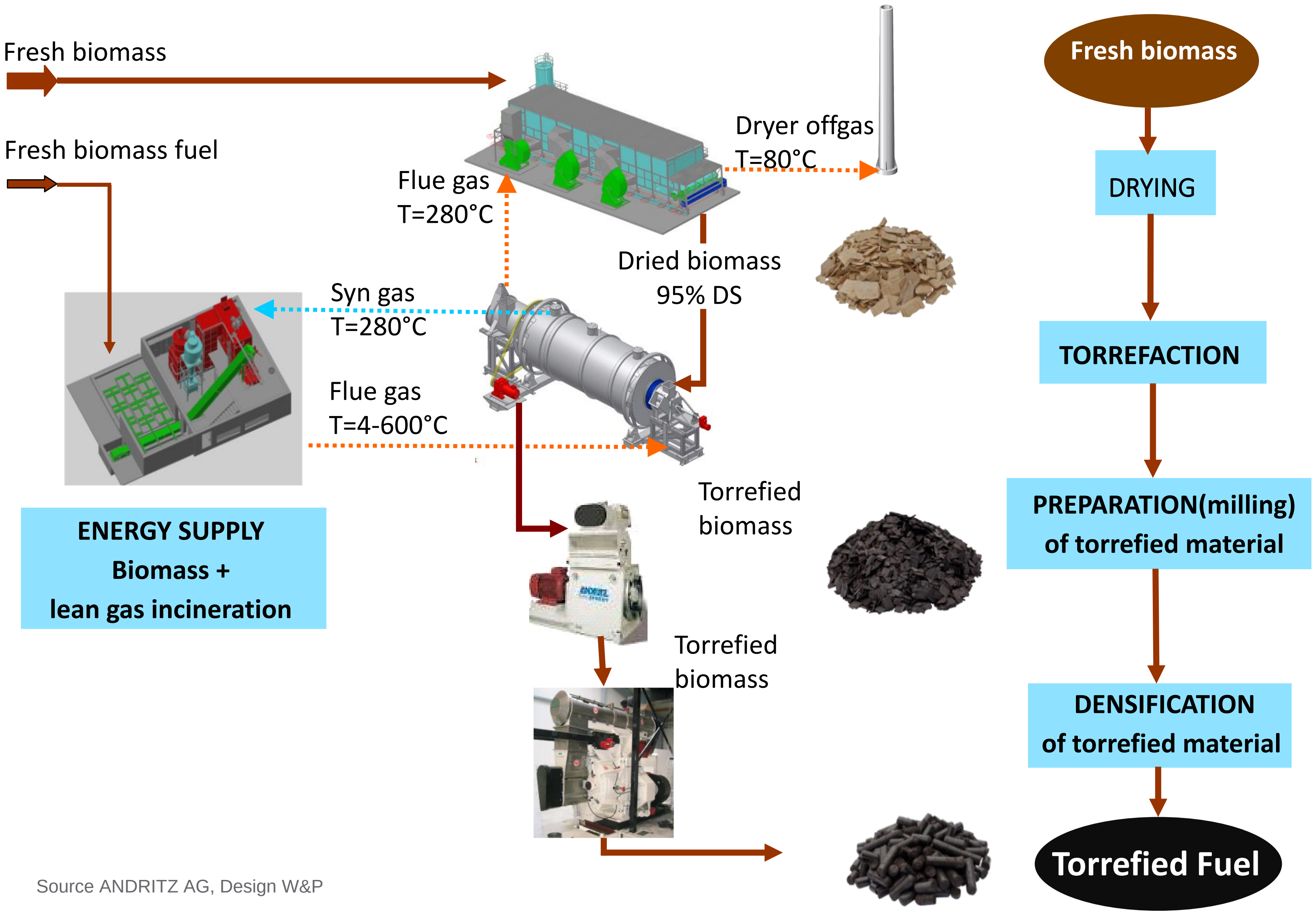
GHG Comparison



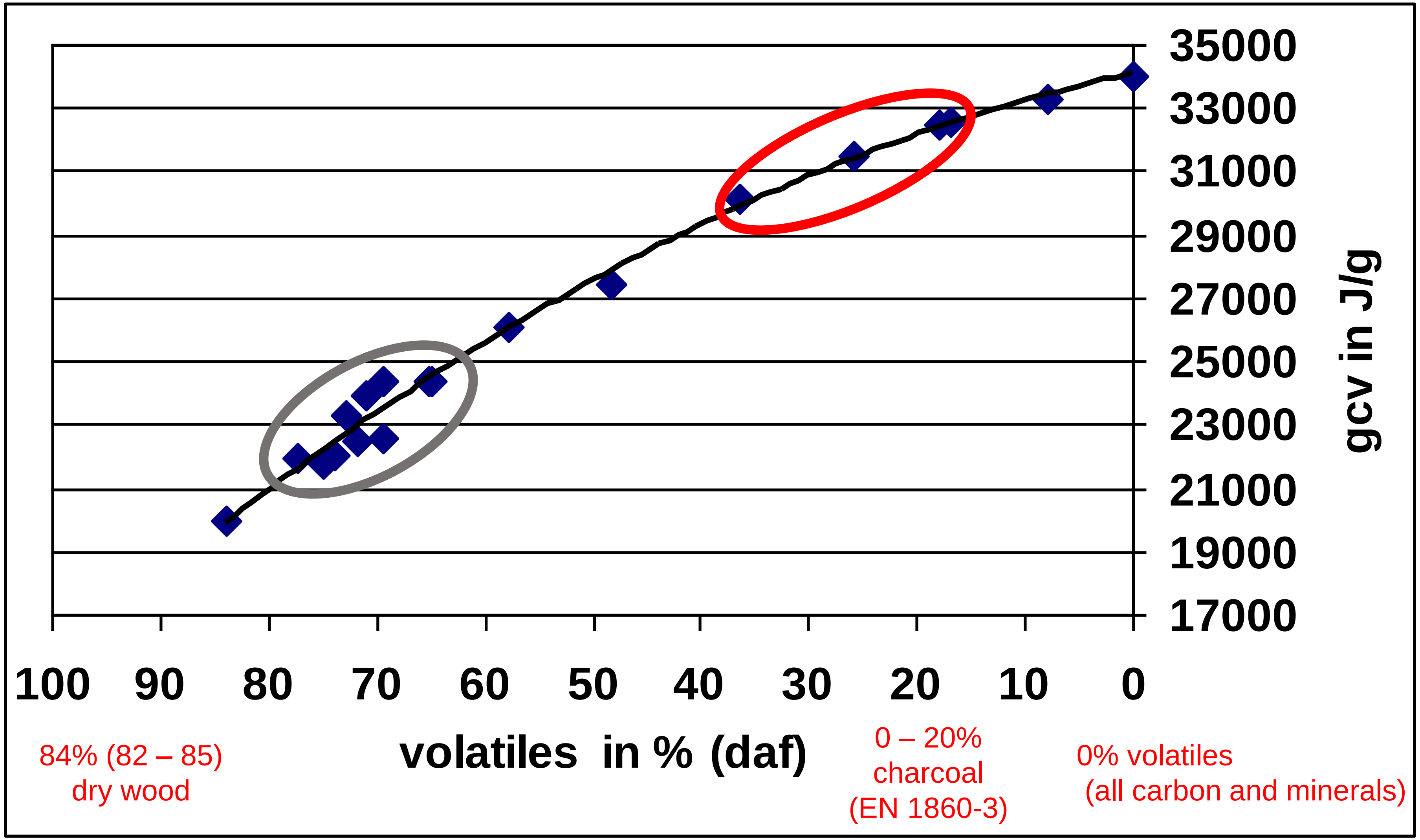
Source: D. Thrän, DBFZ

The torrefaction process (example ACB)



Source ANDRITZ AG, Design W&P

Carbonisation Reaction under Heat



Source and Copyright: IBTC, www.Biomasstorrefction.org

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The Co-carbonization Process

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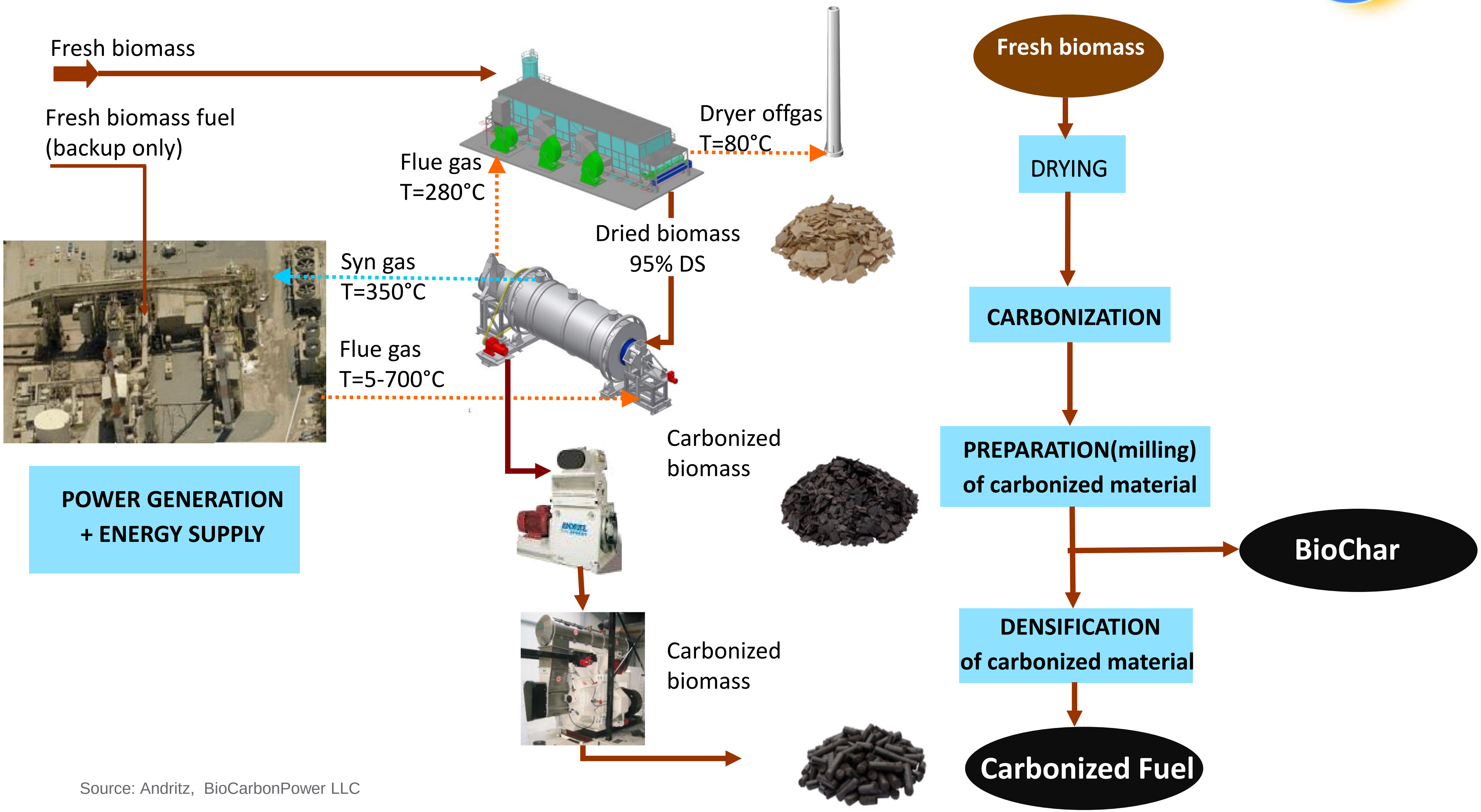

Source: Andritz, BioCarbonPower LLC

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The Co-carbonization Process

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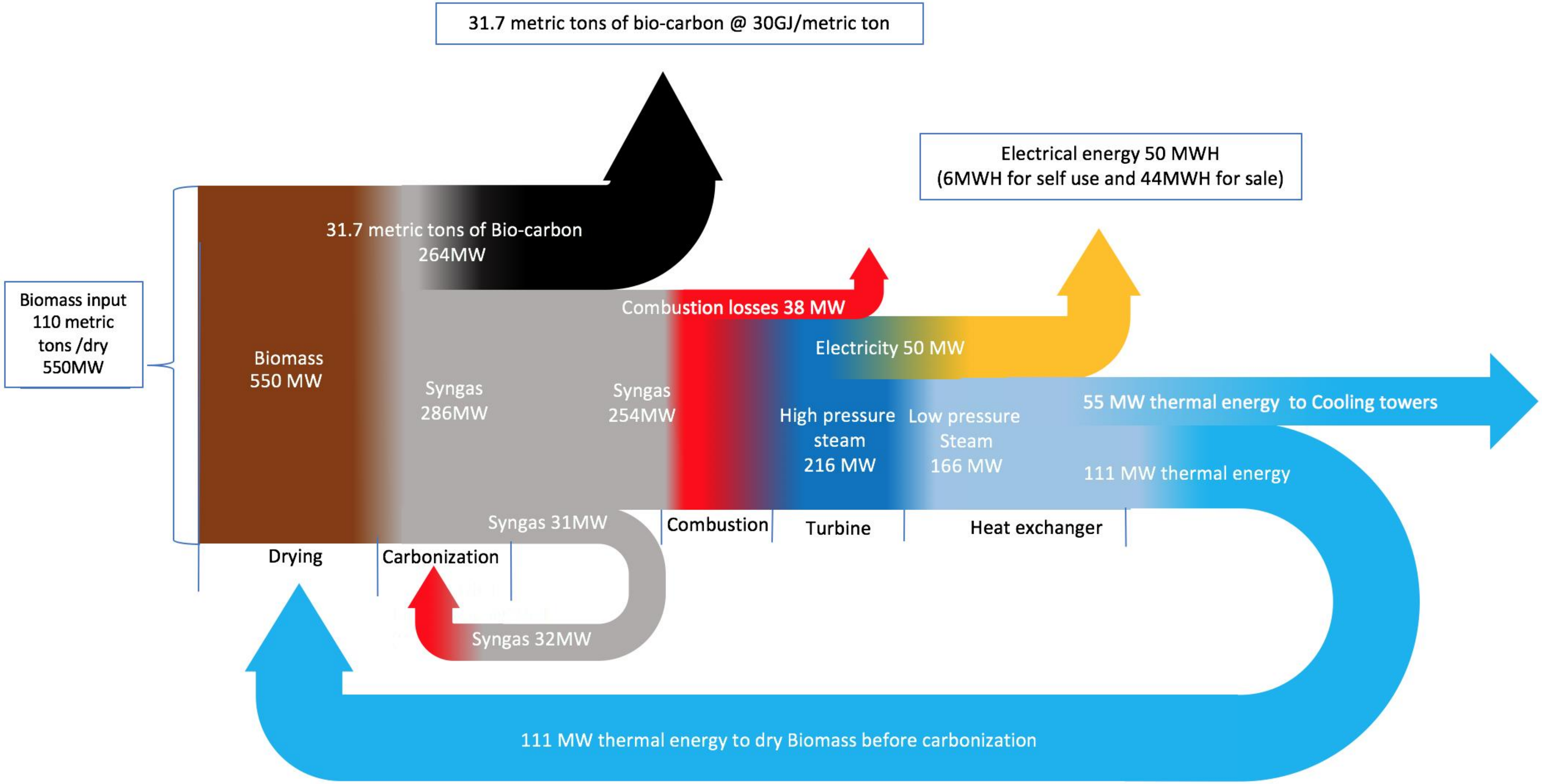
Energy & material balance to produce 31.7 metric ton/hour of bio-carbon and 50 MWH of electricity



Source: BioCarbonPower LLC

Understanding the Fuel Product

- 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

Product Form Factors

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 yet to be defined:

Grindability
Water resistance
Energy balance

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 Value to be stated	Q_d < 21,0 Q_d < 5,8	Q_d ≥ 21,0 Q_d ≥ 5,8 Value to be stated	Q_d < 21,0 Q_d < 5,8	Q_d ≥ 21,0 Q_d ≥ 5,8 Value to be stated	Q_d < 21,0 Q_d < 5,8
Bulk density, BD, ISO 17828	kg/m³ as received	BD650 ≥ 650 Value to be stated	BD700 ≥ 700	BD650 ≥ 650 Value to be stated		BD550 ≥ 550 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.
Selected size D06 or D08 of pellets to be stated for TW1H and TW1L.
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 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 ...).
f 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).
g 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 ...ded 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
	...lue 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
	...e stated	Should be stated	Should be stated

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

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Small-scale outdoor storage

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

- High pellet durability essential for improved weather resistance in time
- Slight degradation outer surface; inner content pile intact

Source: SECTOR, ECN

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Biological Degradation

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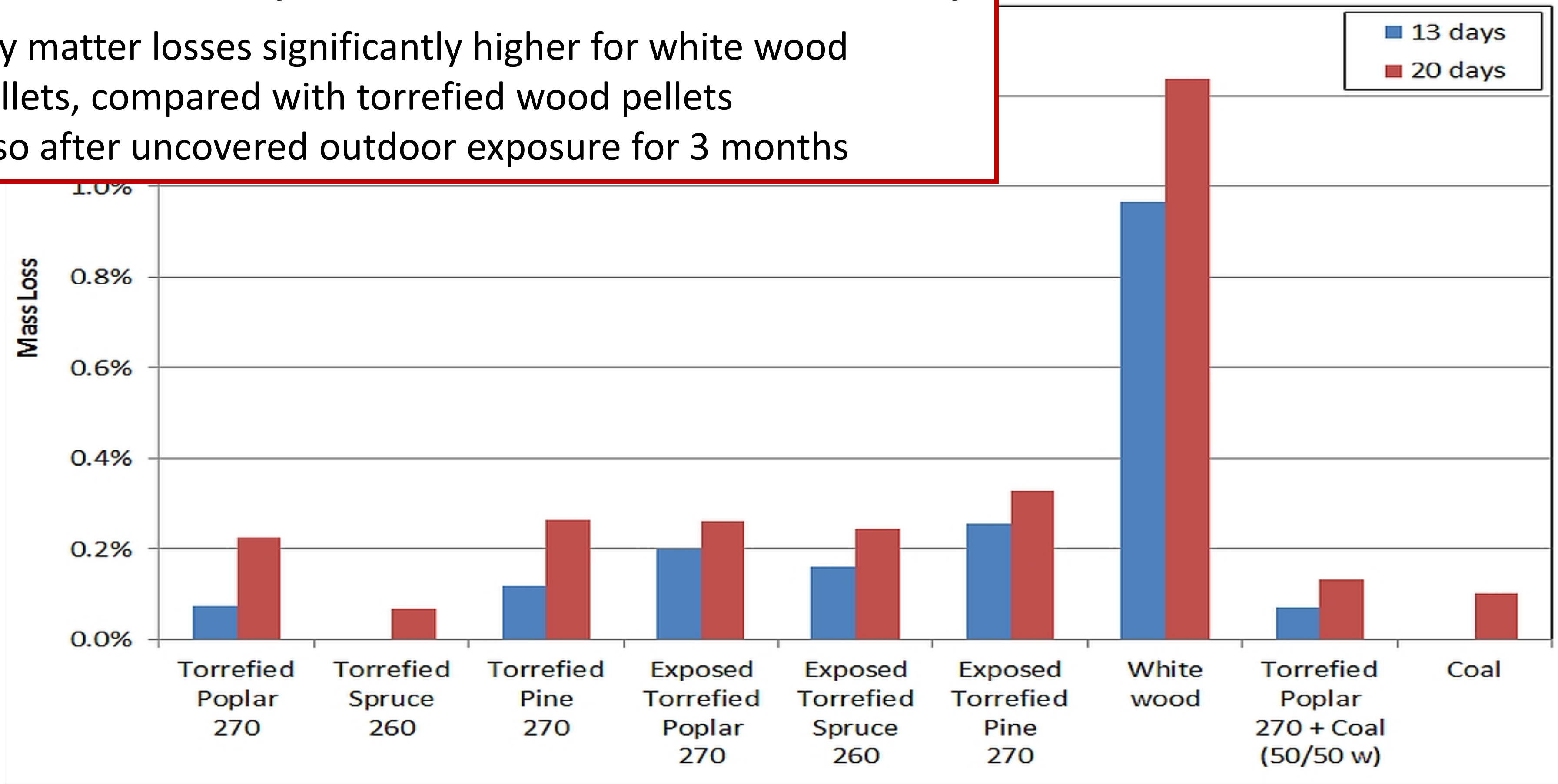
Pellets stored 20 days at 20° C at 95% relative humidity

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

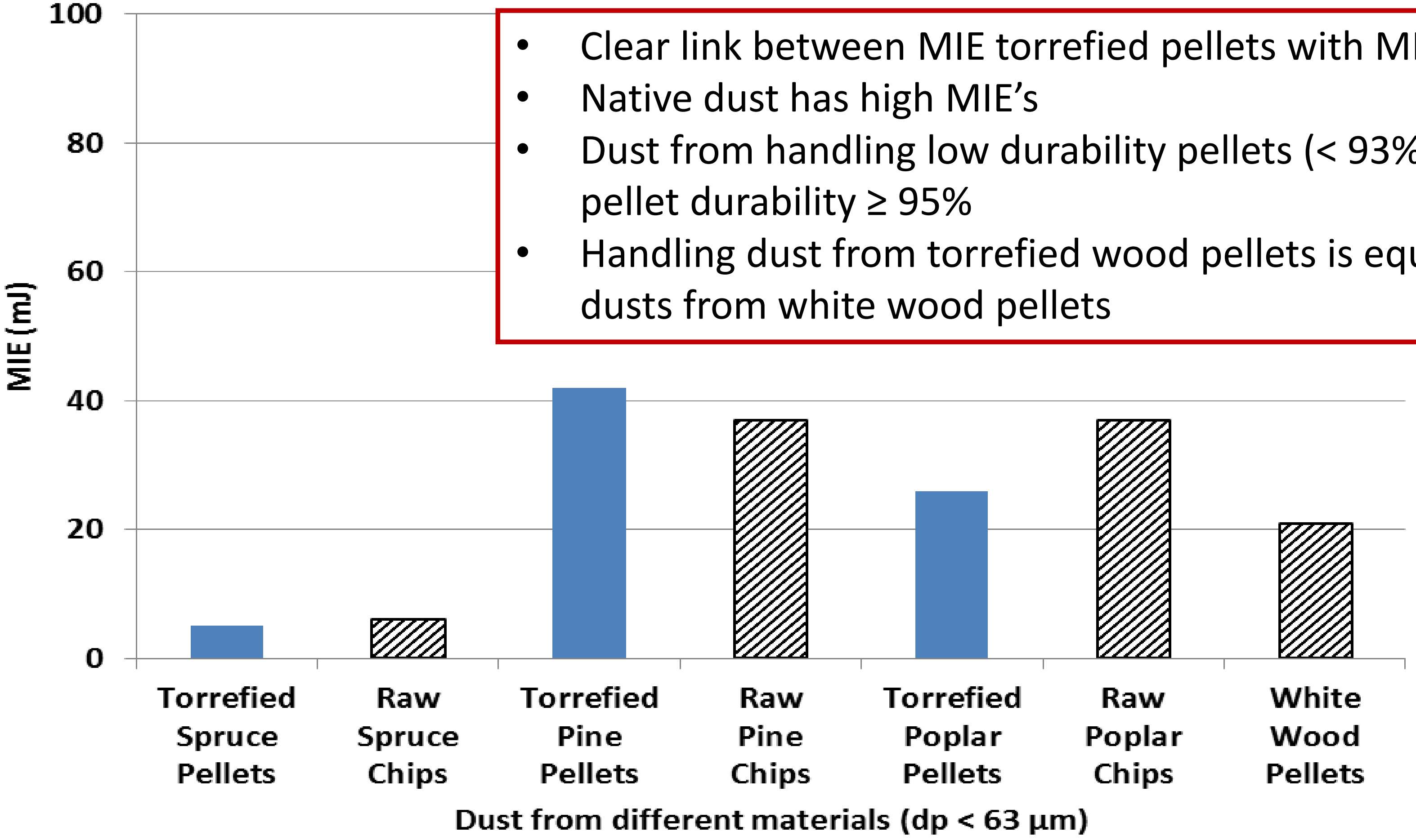


Source: Carbo et al. “Fuel pre-processing, pre-treatment and storage for co-firing of biomass and coal” in “Fuel Flexible Energy Generation” ed. J. Oakey, 2015

Minimum Ignition Energy (MIE)

Pulverised torrefied pellets vs. pulverised raw biomass chips (ind. off)

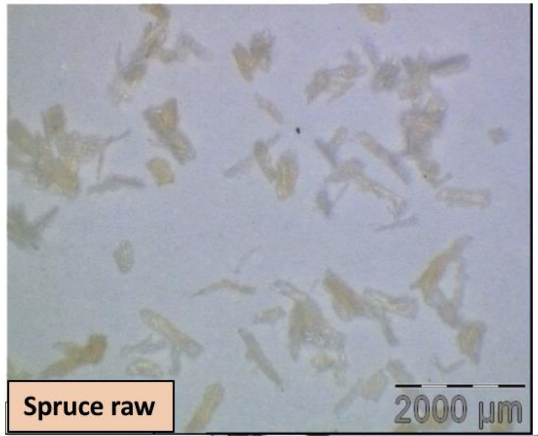
- Clear link between MIE torrefied pellets with MIE raw material
- Native dust has high MIE’s
- Dust from handling low durability pellets (< 93%) is more ignitable → aim for pellet durability ≥ 95%
- Handling dust from torrefied wood pellets is equally ignitable as handling dusts from white wood pellets

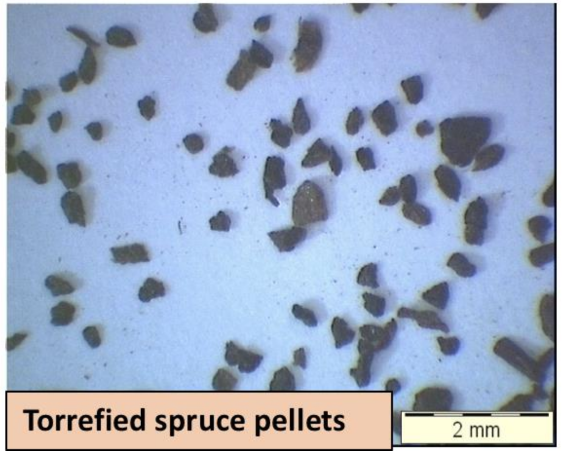


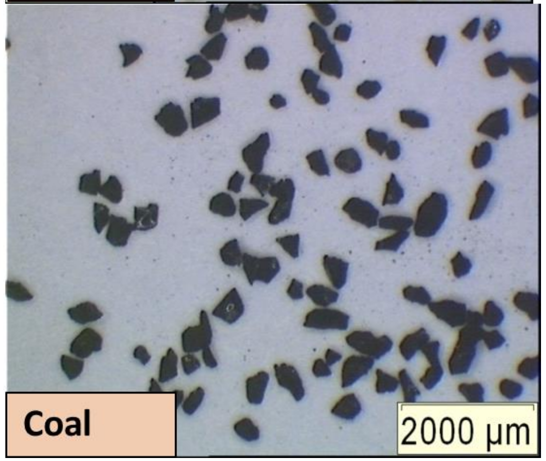
Source: Carbo et al. “Fuel pre-processing, pre-treatment and storage for co-firing of biomass and coal” in “Fuel Flexible Energy Generation” ed. J. Oakey, 2015

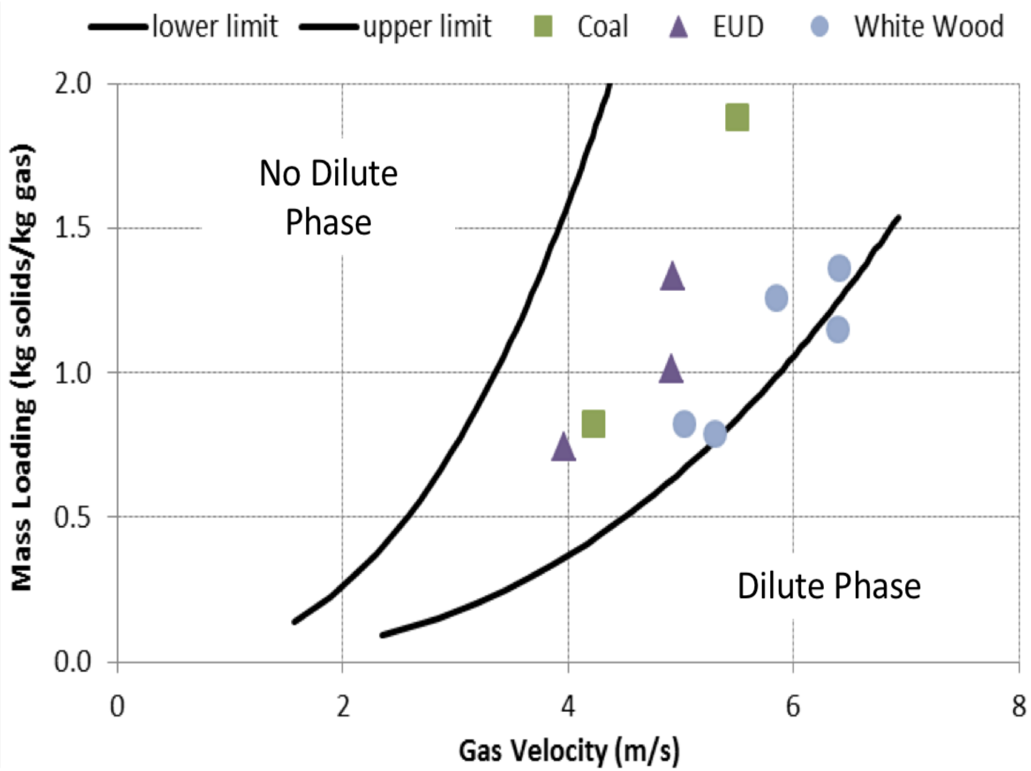
Sphericity of ground Fuels and Pneumatic transport

Particle "sphericity" of pulverised torrefied wood pellets almost identical to pulverised coal









Source: ECN

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Positive Experience in co–firing

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- 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

Many positive examples in co-firing 5-100%:

Vattenfall
Essent - RWE
GDF Suez - ENGIE
Dong
Portland General Electric

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

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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

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

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- 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

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Thank you for paying attention

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