Torrefaction of biomass

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IEA Bioenergy

Task 32: Biomass Combustion and Cofiring

INTERNATIONAL BIOMASS TORREFACTION COUNCIL

IEA Bioenergy task 32: Biomass Combustion and Cofiring

- Experts from 12 countries:
  - Austria, Belgium, Denmark, Germany, Ireland, Japan, Netherlands, Norway, South Africa, Sweden, Switzerland, United Kingdom
- Working together in:
  - Cooperative projects
  - Meetings, Workshops, Conferences, Excursions
  - Cooperation with other Networks
- Reports etc. can be found on our website:
  - www.ieabioenergytask32.com

INTERNATIONAL BIOMASS TORREFACTION COUNCIL

- Bringing together the performing companies in Torrefaction
- Promoting the uptake of torrefied biomass for Energy
- All issues of common interest which are not under competition
- Regulatory Barriers, general permissions along supply chain
- Link to Policy
- Safety and Health
- First contact for everybody interested in Biomass Torrefaction

INTERNATIONAL BIOMASS TORREFACTION COUNCIL

AEBIOM
EUROPEAN BIOMASS ASSOCIATION

IBTC Full Members

AIREX ENERGY

KAHL

ANDRITZ

AREVA

Arigna Fuels Ltd
Manufacturers of Quality Smokeless Fuels

ATP
Agri-Tech Producers, LLC

BIOLAKE

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GDF SUEZ

RIVER BASIN ENERGY INC

Rotawave

SOLVAY BIOMASS ENERGY

Topell Energy

TORBED Energy technologies

TORR COAL

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IBTC Supporting Members

Advanced Torrefaction Systems, LLC

CPL INDUSTRIES

DNV·GL

ECN
Your energy. Our passion.

SB
Systèmes Industriels de Bioénergie

MIKTECH

BioEndev

SEEGER ENGINEERING

VISION ENERGY GROUP

Torrefaction is like roasting coffee….

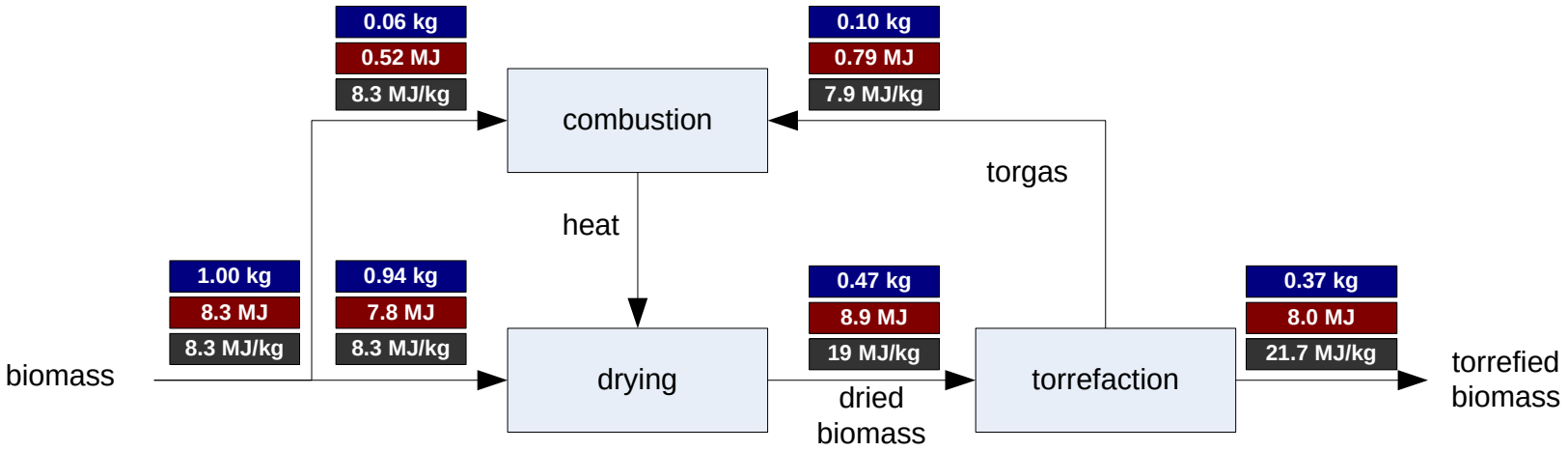
- Heating biomass to 250-350 °C in absence of oxygen
- Drying + removal of part of the volatiles

roasting

Claims made for Torrefaction

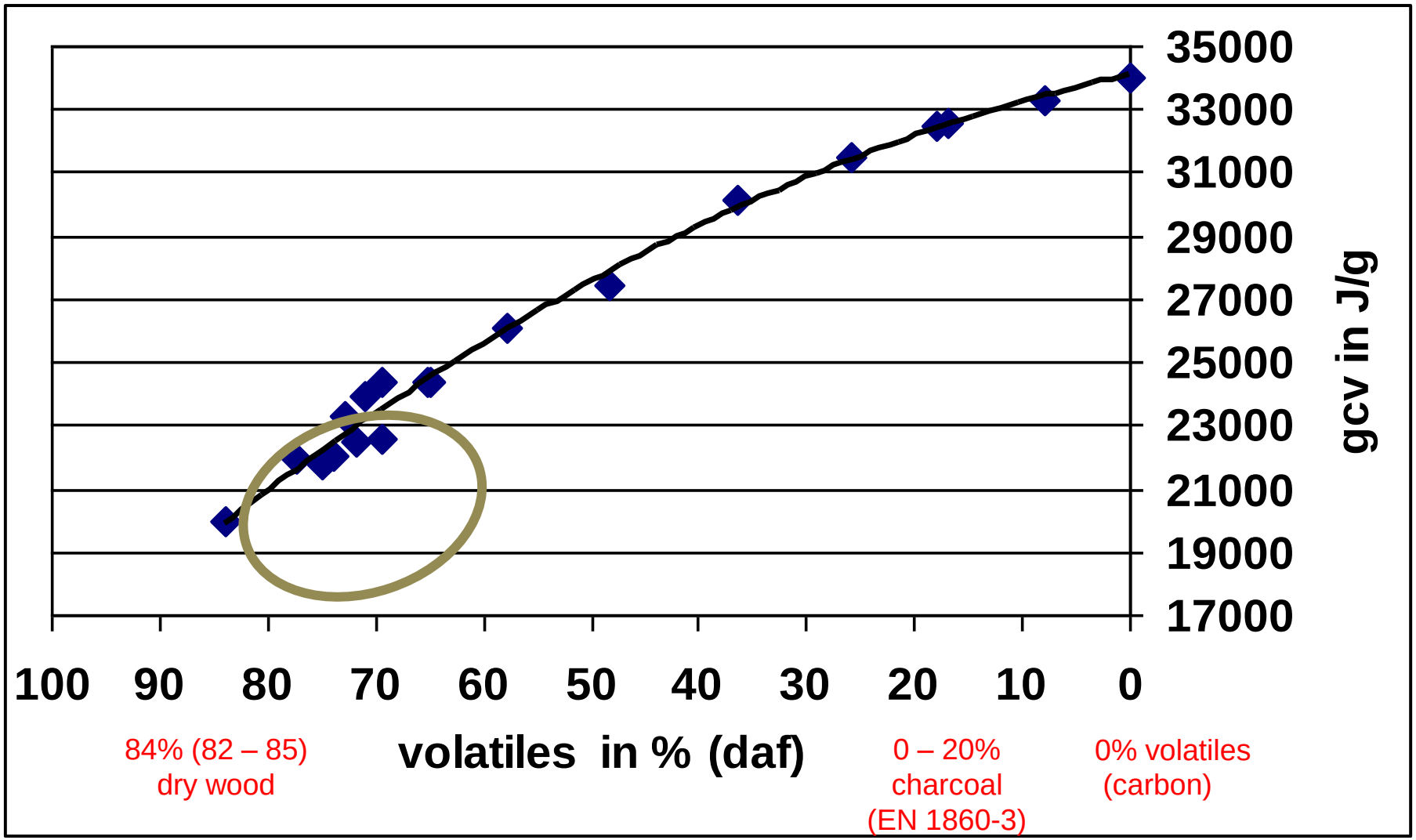
1. Volumetric energy densification brings significant cost reductions in transport and handling
2. Broader feedstock basis - geographically + types of raw material
3. Limited or no biodegradation of product when stored
4. Large variety of applications
5. Reduces CAPEX&OPEX at end user – Immediate use in existing coal fired plants – grindability, (water resistance?)....
6. Combustion and gasification behaviour more compatible to coal than raw biomass, high cofiring shares possible
7. Can be made to measure to clients requirements
8. Helps developing the market towards commoditisation

Heat energy balance (LHV basis)

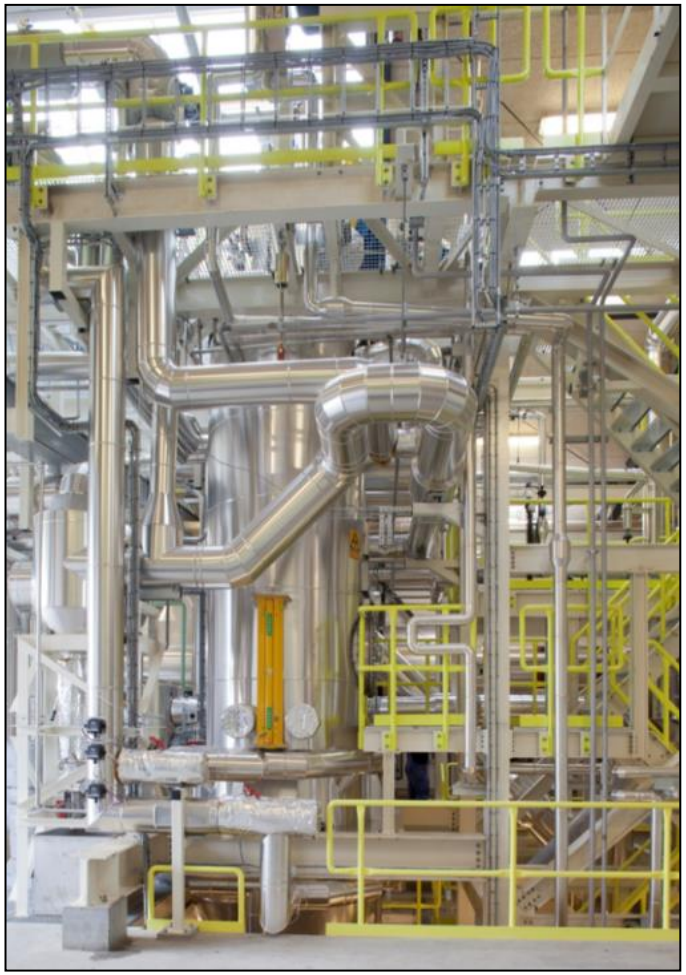


Assumptions: fresh clean wood (0,5% ash content, 50% moisture content) as raw material and a dryer requiring 2.9 MJ per kg of water evaporated

Carbonisation Reaction under Heat



The technology is available now

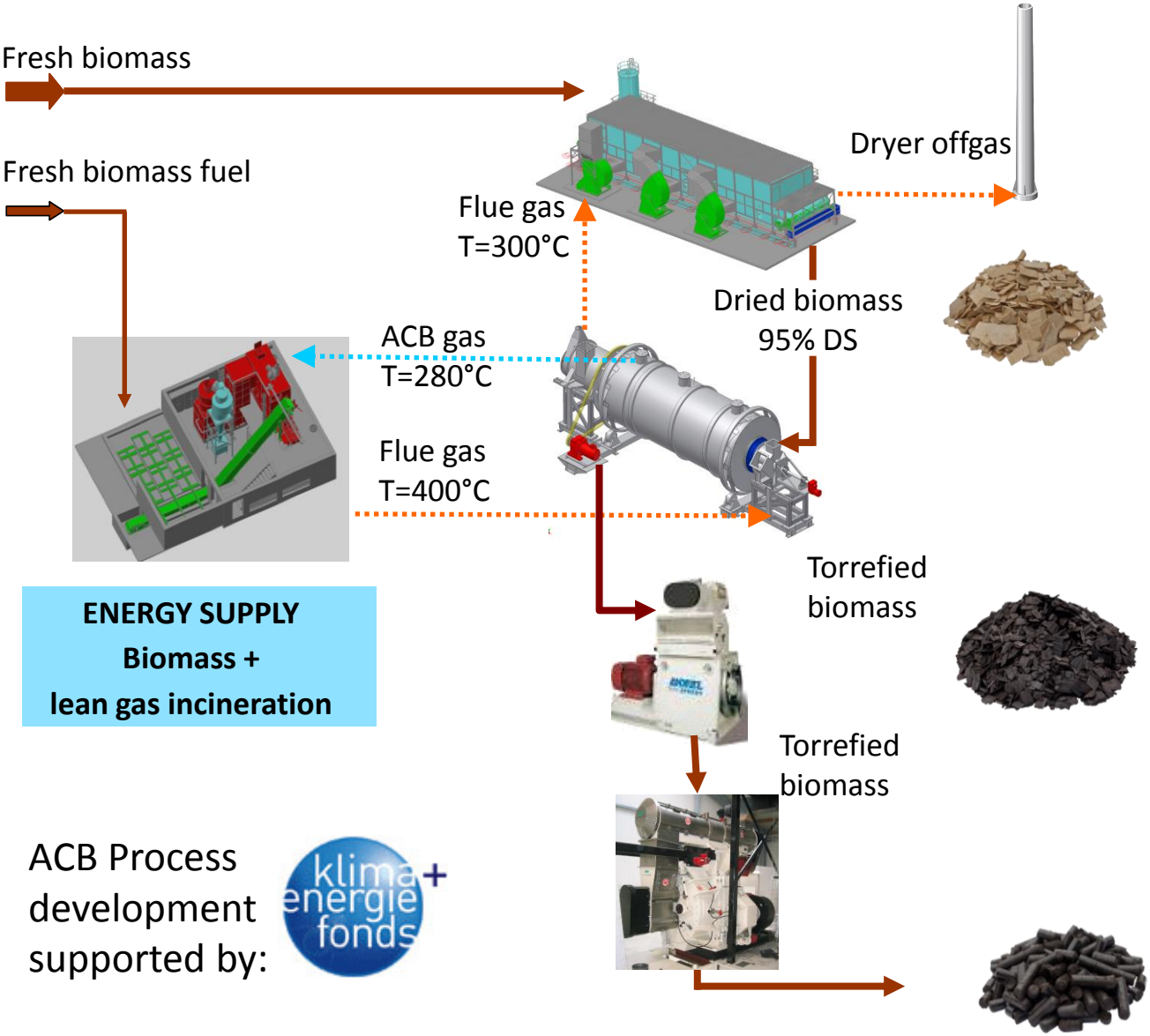


Several companies are involved

(IEA Bioenergy Task 32 torrefaction review, 2012)

Developer	Technology	Supplier	Location(s)	Production capacity (t/a)	Status and scale Pilot scale: 50 kg/h – 500 kg/h Demo scale: > 500 kg/h – 2 t/h Commercial : > 2t/h)
Agri-Tech Producers LLC (US/SC)	Belt reactor	Kusters Zima Corporation (US/SC)	Unknown	Unknown	Pilot stage
Airex	Cyclonic Bed reactor	Airex	Laval, QC	Unknown	Pilot stage
Airless systems	Unknown	Atmosclear	Latvia	40,000	Out of business
Atmosclear SA (CH)	Rotary drum	CDS (UK)	Latvia, New Zealand, USA	50,000	Out of business
Bioenergy Development & Production	Fluidised Bed	Bioenergy Developmt & Production	Nova Scotia, CAN	?	Pilot
Bio Energy Development North AB (SWE)	Rotary drum	Unknown	Ö-vik (SWE)	25,000	
BioLake B.V. (NL)	Screw conveyor	Unknown	Eastern Europe	5,000 – 10,000	Pilot stage
Earth Care Products	Rotary drum	Earth Care Products	Kansas (USA)	20,000	Demonstration / commercial
EBES AG (AT)	Rotary drum	Andritz (AT)	Frohnleiten (AU)	10,000	1 mt/hr pilot plant in commissioning
ECN (NL)	Moving bed	Andritz (AT)	Stenderup (DK)	10,000	ECN combines technology with Andritz
FoxCoal B.V. (NL)	Screw conveyor	Unknown	Winschoten (NL)		Pilot, company now bankrupt
HM3 Energy	unknown	HM3	Oregan, US	?	Pilot building Demo plant
Integro Earth Fuels, LLC (US/NC)	TurboDryer	Stopped with Wyssmont (US/NC)	Roxboro, NC	80,000	Pilot stage
New Biomass Energy	Screw reactor	New Biomass Energy	Quitman, Mississippi, USA	40,000 160,000	Existing Commissioning
New Earth Renewable Energy Fuels, Inc (US/WA)	Fixed bed	Unknown	Unknown	Unknown	Out of business
Renergy/4Energy Invest (BE)	Rotary Drum	Stramproy Green Technology (NL)	Amel (BE) , Ham (Be)	38,000	Project terminated
Renergy/4Energy Invest (BE)	Rotary Drum	Stramproy Green Technology (NL)	Ham (Be)	38,000	Project terminated
River Basin Energy	Fluidised bed reactor	River Basin Energy	Laramie, Wyoming, USA	48,000	Pilot stage
Rotawave, Ltd. (UK)	Microwave reactor	Group's Vikoma	Terrace, British Columbia (CA)	110,000	Stopped in BC, announced partnership with Cate Street capital (Maine)
Horizon Bioenergy. (NL)	Oscillating belt conveyor	Stramproy Green Technology (NL)	Steenwijk (NL),	45,000	Operational again after plant fire in Feb 2012
Thermya (FR) / Grupo Lantec (SP)	Moving bed	Thermya (Fr)	Urnieta (SP)	20,000	Early stage commissioning
Thermya (FR) / LMK Energy (Fr)	Moving bed	Thermya (Fr)	Mazingarbe (Fr)	20,000	Early stage commissioning
Topell Energy B.V. (NL)	Torbed	Torftech Inc (UK)	Duiven (NL)	60,000	Final stage of commissioning
Torr-Coal B.V. (NL)	Rotary Drum	Unknown	Dilsen-Stokkem (BE)	35,000	
Torrefaction Systems Inc. (US)	Unknown	Bepex International (US/MN)	Unknown	Unknown	Pilot
WPAC (CA)	Unknown	Unknown	Unknown	35,000	
Wyssmont	turbodryer	wyssmont	US	Unknown	Unknown

The torrefaction process (example ACB)

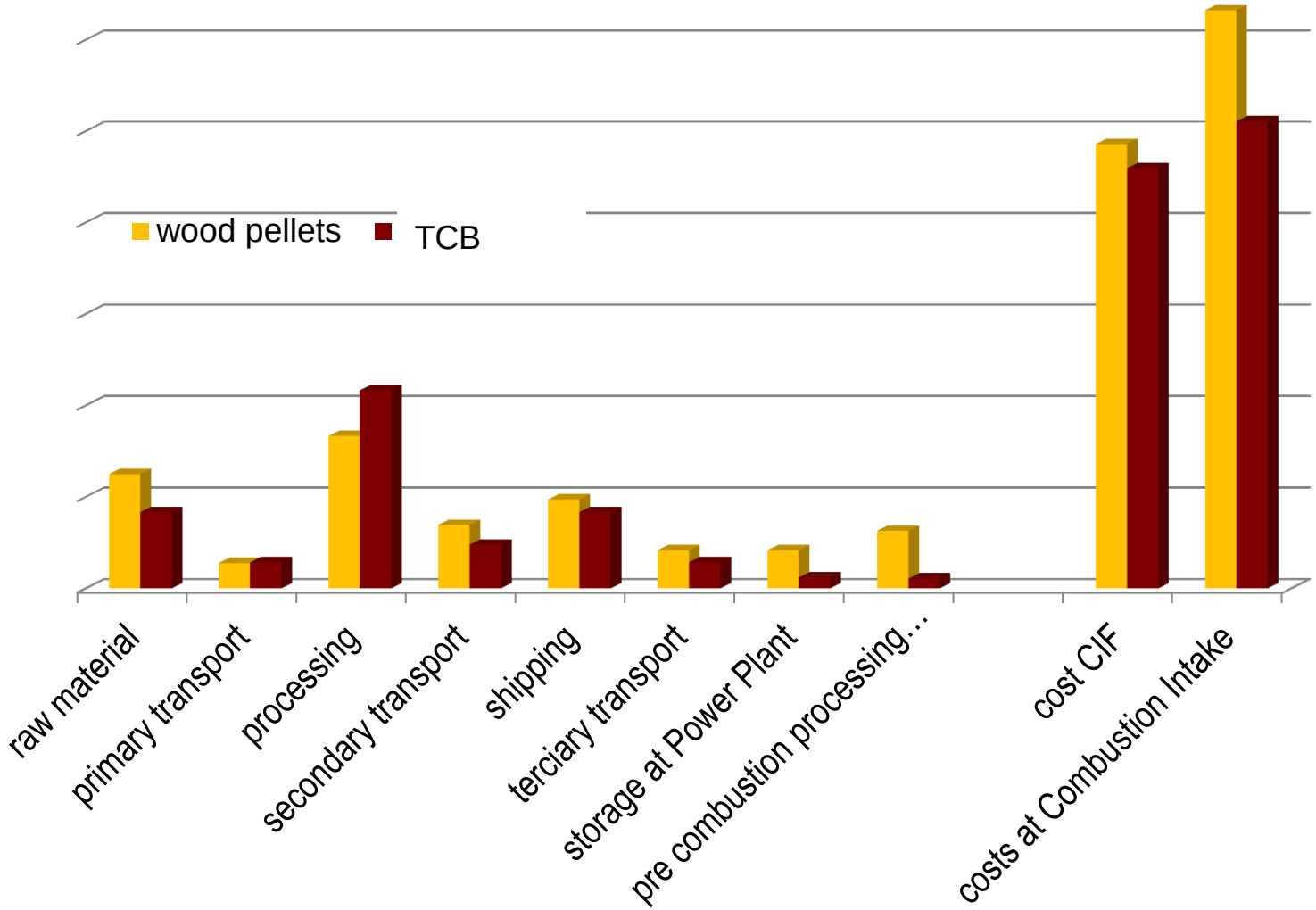


ACB Process development supported by:

Products available today

Source: Andritz AG

Cost comparison US$/GJ CIF ARA



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Topell case study: Results (USD/GJ)

Cost components	Wood Pellets	Torrefied Pellets	Savings
Cost of Biomass	4.28	4.28	0.00
Cost of Electricity	0.60	0.45	0.15
Cost of Labour	0.47	0.47	0.01
Financial costs	1.01	1.49	-0.49
Other costs	0.40	0.43	-0.02
COST PRICE AT PRODU	6.76	7.11	-0.35
Inland logistics from	1.12	0.57	0.55
Deep sea shipment	2.04	1.28	0.76
Inland logistics from the port to utility	(	0.55	0.39
COST PRICE DELIVERED AT THE POWER PLANT		9.51	1.36
Extra costs at the power plant		-	1.93
Total costs of coal replacement	.30	9.51	3.29

Difference with coal is about 50 USD/ton CO_2

Key fuel characteristics for an end user

- Bulk density
- Composition
- Heating value
- Combustion behaviour in a boiler
- Grindability
- Water resistance
- Energy balance
- Health and safety aspects (MEC, self heating…)

Quality – Standardisation

- **New Work Item ISO 238 WG 2**
  ISO 17225: Solid biofuels – Fuel specifications and classes – Part XX: Thermally Treated Pellets
- **Comments will be collected by national standardisation committees**
- **You can address IBTC with comments and requirements**

Table 1 — Specification of graded pellets produced from thermally treated woody biomass

Property class, Analysis method	**Unit**	**TW1**	**TW2**	**TW3**
Normative				
Origin and source, ISO 17225-1		1.1.1 Whole trees without roots 1.1.3 Stemwood 1.1.4 Logging residues 1.2.1 Chemically untreated wood 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; 3,15 < L ≤ 40 D08, 8 ± 1; 3,15 < L ≤ 40	D06, 6 ± 1; 3,15 < L ≤ 40 D08, 8 ± 1; 3,15 < L ≤ 40	D06, 6 ± 1; 3,15 < L ≤ 40 D08, 8 ± 1; 3,15 < L ≤ 40
Moisture, M, ISO 18134-1, ISO 18134-2	as received, w-% wet basis	M08 ≤ 8	M08 ≤ 8	M08 ≤ 8
Ash, A, ISO 18122	w-% dry	A2.0 ≤ 2,0	A5.0 ≤ 5,0	A7.0 ≤ 7,0
Mechanical durability, DU, ISO 17831-1	w-% as received	DU97.5 ≥ 97,5	DU96.5 ≥ 96,5	DU95.0 ≥ 95.0
Fines, F [d], ISO 18846	w-% as received	F1.0 ≤ 1,0	F2.0 ≤ 2,0	F2.0 ≤ 2,0
Additives [e]	w-% dry	≤ 10 Type and amount to be stated	Type and amount to be stated	Type and amount to be stated
Net calorific value, Q, ISO 18125	MJ/kg or kWh/kg dry	Q19 ≥ 19 or Q5.3 ≥ 5,3 Value to be stated	Q19 ≥ 19 or Q5.3 ≥ 5,3 Value to be stated	Q18 ≥ 18 or Q5.0 ≥ 5,0 Value to be stated
Bulk density, BD, ISO 17828	kg/m^3 as received	BD650 ≥ 650 Value to be stated	BD650 ≥ 650 Value to be stated	BD650 ≥ 650 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	N0.5 ≤ 0,5	N0.5 ≤ 0,5	N1.0 ≤ 1,0
Sulfur , S, ISO 16994	w-% dry	S0.04 ≤ 0,04	S0.04 ≤ 0,04	S0.05 ≤ 0,05
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	≤ 1	≤ 1	≤ 1
Chromium, Cr, ISO 16968	mg/kg dry	≤ 15	≤ 15	≤ 15
Copper, Cu, ISO 16968	mg/kg dry	≤ 20	≤ 20	≤ 20
Lead, Pb, ISO 16968	mg/kg dry	≤ 10	≤ 10	≤ 10
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 [f], CEN/TS 15370-1 [1]	°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.
[c] Amount of pellets longer than 40 mm can be 1 w-%. Maximum length shall be ≤ 45 mm.
[d] At factory gate in bulk transport (at the time of loading) and in small (up to 20 kg) and large sacks (at time of packing or when delivering to end-user). 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] All characteristic temperatures (shrinkage starting temperature (SST), deformation temperature (DT), hemisphere temperature (HT) and flow temperature (FT)) in oxidizing conditions should be stated.

Documentation, Permissions and Registrations

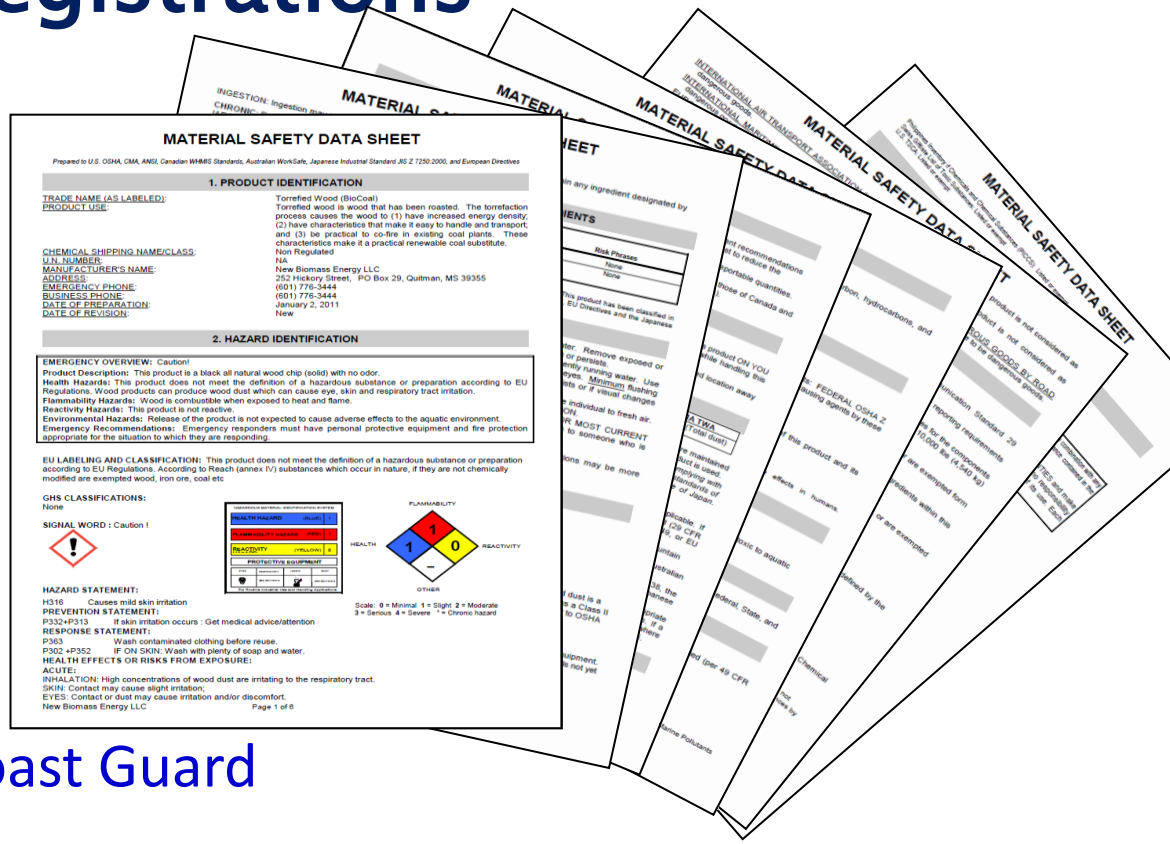
MSDS

REACH

Customs CODE EU

IMO, IMSBC code

Department of
Homeland Security/US Coast Guard
3 years permit



To develop/receive this extensive tests have been carried out:
Results all equal or superior to wood pellets

Dust, Self Heating, Spontaneous Ignition

- Torrefied dust similar to normal biomass dust, but clearly more reactive than coal dust. Risk of dust explosions and self-ignition similar to wood dust
- Torrefied wood pellets are drier and more brittle than conventional wood pellets. Severe dusting during the unloading and conveying of torrefied pellets may be expected hence smooth handling is obligatory
- Hazards for self heating should not be neglected in the large-scale storage of any fuel.

Source: VTT TECHNOLOGY 122

Water Uptake

ACB - Weather test prelim. results briquettes

Briquette Quality before and after:

Briquettes (D=70mm, spruce,
production 10.04)
filled in a box of 1,4 m height and been stored outside

After 43 days of storage box has been dismantled and briquette quality evaluated

Rainfall during storage time:

21 rainfalls have been documented
3 rainfalls with > 20 mm/m^2

Sample 1

Sample 2

Eluation, Ecotoxicity

BET Surface is reduced

	Probe 1 R	Probe 1 P	Probe 2 R
Spezifische Oberfläche (m^2/g)	1,96	1,72	1,19

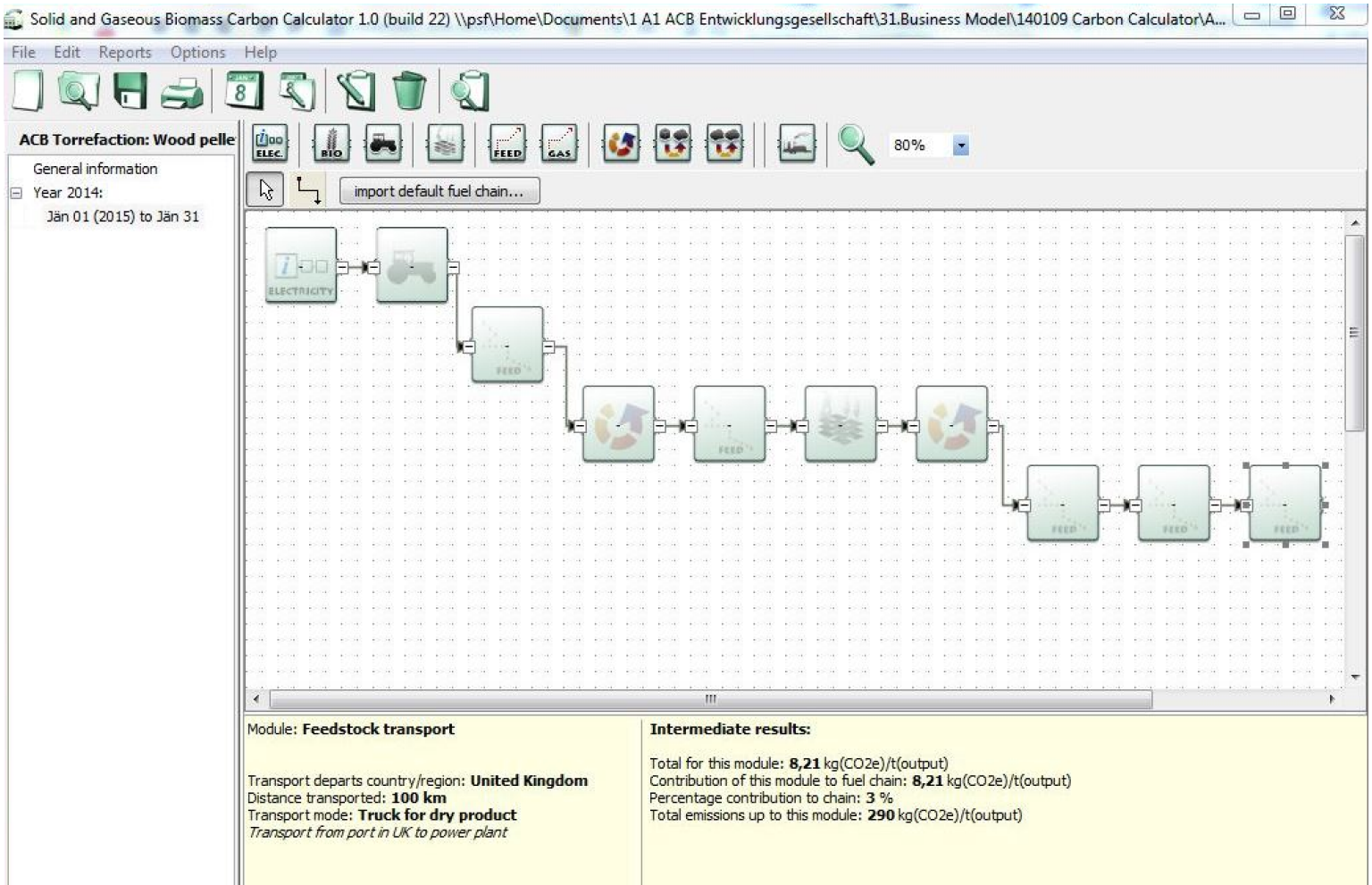
Daphnientests **>1/8** dilution of Eluate below the analytical limit of determination

Proof of non toxic character of leaching water against fish DIN 38412 Teil 31

Source: Torrlog

CO_2 Value Comparison

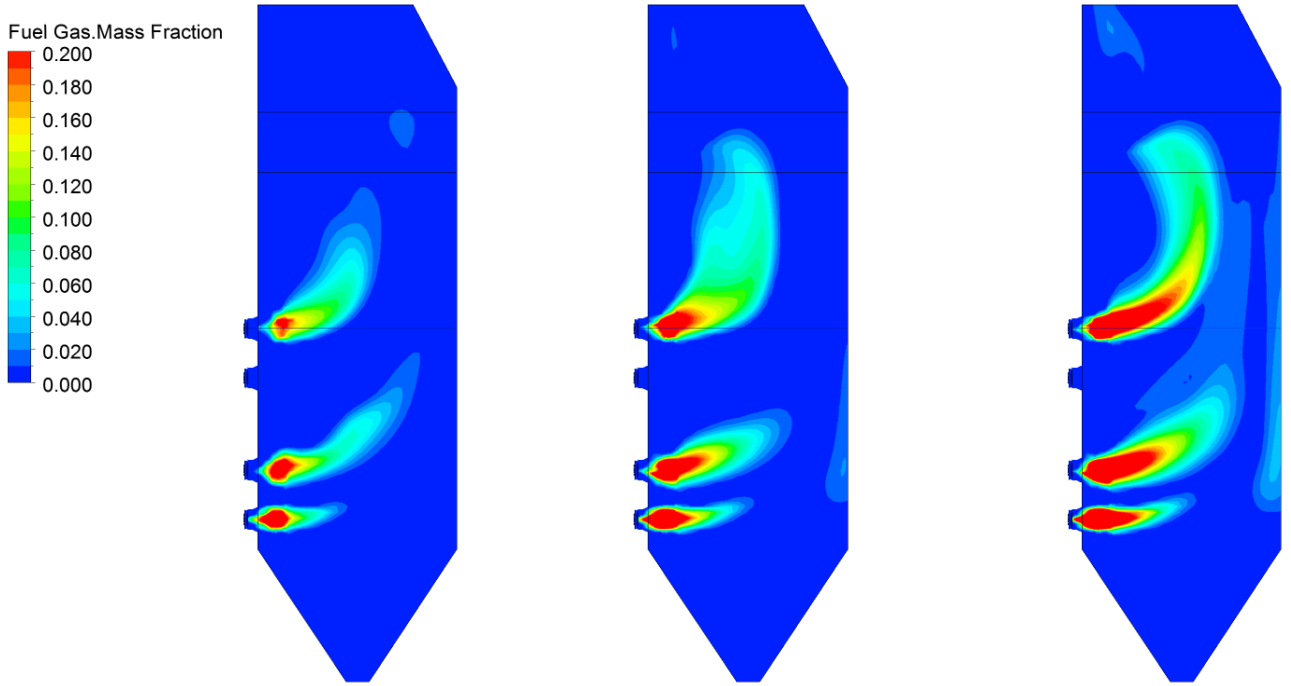
- Comparison of White Wood Pellets with Torrefied Wood Pellets supplied from South East USA to UK
- CO_2 Emissions along supply chain calculated with OFGEM Solid and Gaseous Carbon Calculator are in the same range and directly comparable



Combustion behaviour in a PC boiler

- Lack of water resistance may require covered storage
- Possible to grind as coal
- More volatiles, more reactive than coal
- Ash percentage increases
- Cl may be partly removed
- Higher combustion temperature than biomass (lower than coal)
- Lower amounts of unburned carbon in ash

Position of the reaction zone



100% coal | 50% coal/50% TWP | 100% TWP

Technical challenges remaining

- Water resistance not as good as wanted
- Pelletisation is difficult for material with high torrefaction degree, both high durability and good grindability is difficult to achieve
- Several process owners are unable to produce adequate product at constant quality
- Torrefied wood pellets can generate larger amounts of explosive fine dust than wood dust
- Ash content increases and alkali concentration can go above technical limits for boilers (but Cl may go down)

Conclusions (1/2)

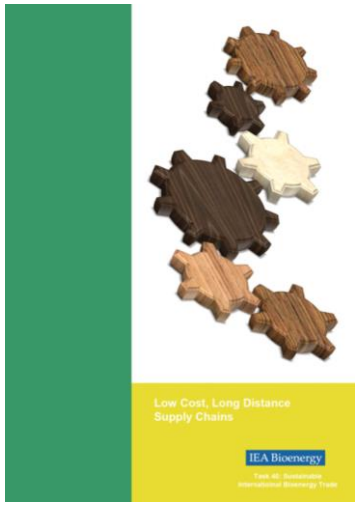
- It potentially offers better cost benefit ratio of solid biomass
- Further cost reductions by using low cost biomass
- No need for additional permits foreseen so far
- Product quality is well defined by ISO standard soon
- First full scale cofiring trials succesfully implemented, more extensive test burns needed in both power and heat applications
- Remaining technical issues to be resolved are related to densification, hydrophobicity, dust mitigation

Conclusions (2/2)

- High market expectations of 3-5 y ago have not been met sofar
- Technology now commercially offered turn key by several companies.
- Topell, NBE, Andritz and many others have (had) their processes in place, several have stopped or gone bankrupt
- Low CO_2 price and lack of other cofiring incentives is a hurdle for market implementation
- Securing financing is a hurdle due to the difficulty in obtaining long term offtake contracts

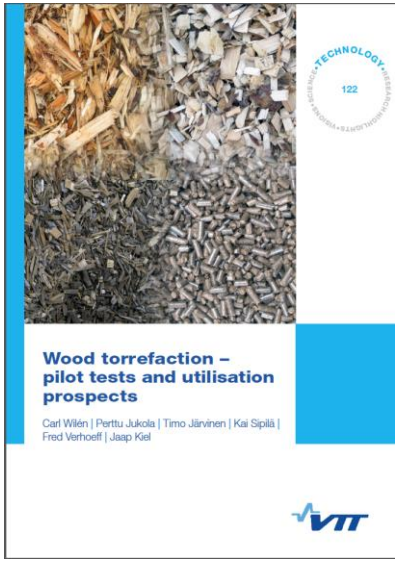
More information

International Biomass Torrefaction Council http://www.aebiom.org/blog/ibtc/

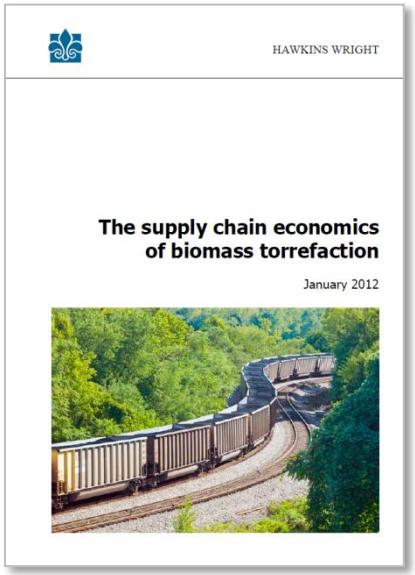


http://www.bioenergytrade.org/

www.ieabioenergytask32.com



VTT Technology 122
http://www.vtt.fi/publications/index.jsp



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Thank you for your attention

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