IEA Bioenergy

Biomass Torrefaction

Technology Status and Commercialisation, Applications for Torrefied Biomass and its Role in Logistics and Trade

Webinar, 27 Oct 2016

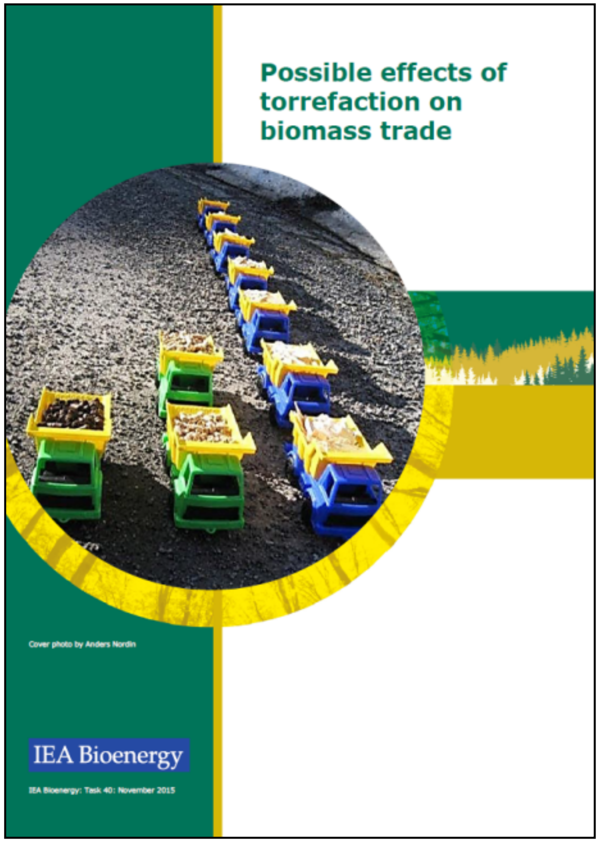
Jaap Koppejan, Managing Director, Procede Biomass BV

Marcel Cremers, Senior Consultant, DNV GL

Michael Wild, President, IBTC

Martin Junginger, Professor Biobased Economy, Utrecht University

Webinar based on two recent reports by tasks 32 and 40



Presenters today

10 min	Introduction to torrefaction, **Jaap Koppejan**, Managing Director, Procede Biomass BV and Task leader IEA Bioenergy Task 32 (Biomass Combustion and Cofiring)
15 min	Status of commercialisation, **Marcel Cremers**, Senior Consultant, DNV-GL
15 min	Possible implications on bioenergy trade, **Michael Wild**, President, International Biomass Torrefaction Council
20 min	Q&A, **Martin Junginger**, Professor Biobased Economy, Utrecht University and Task leader, IEA Bioenergy Task 40 (Biomass Trade)

Torrefaction is like roasting coffee beans….

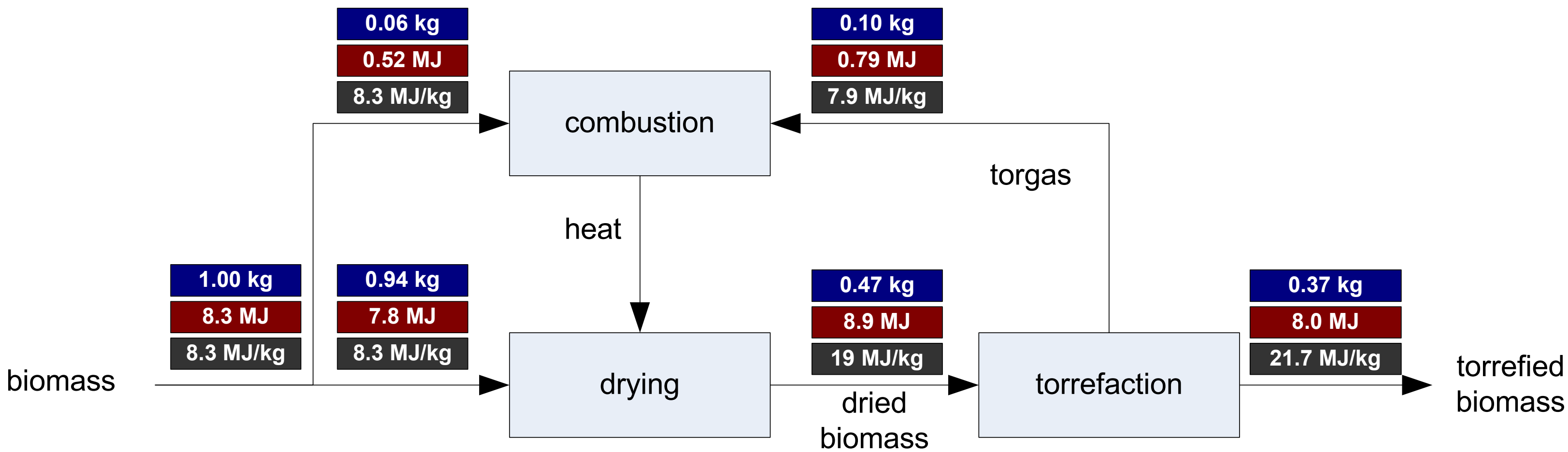
- Heating biomass to 250-300 °C in absence of oxygen
- Drying + removal of part of the volatiles

roasting

Claims made for Torrefaction

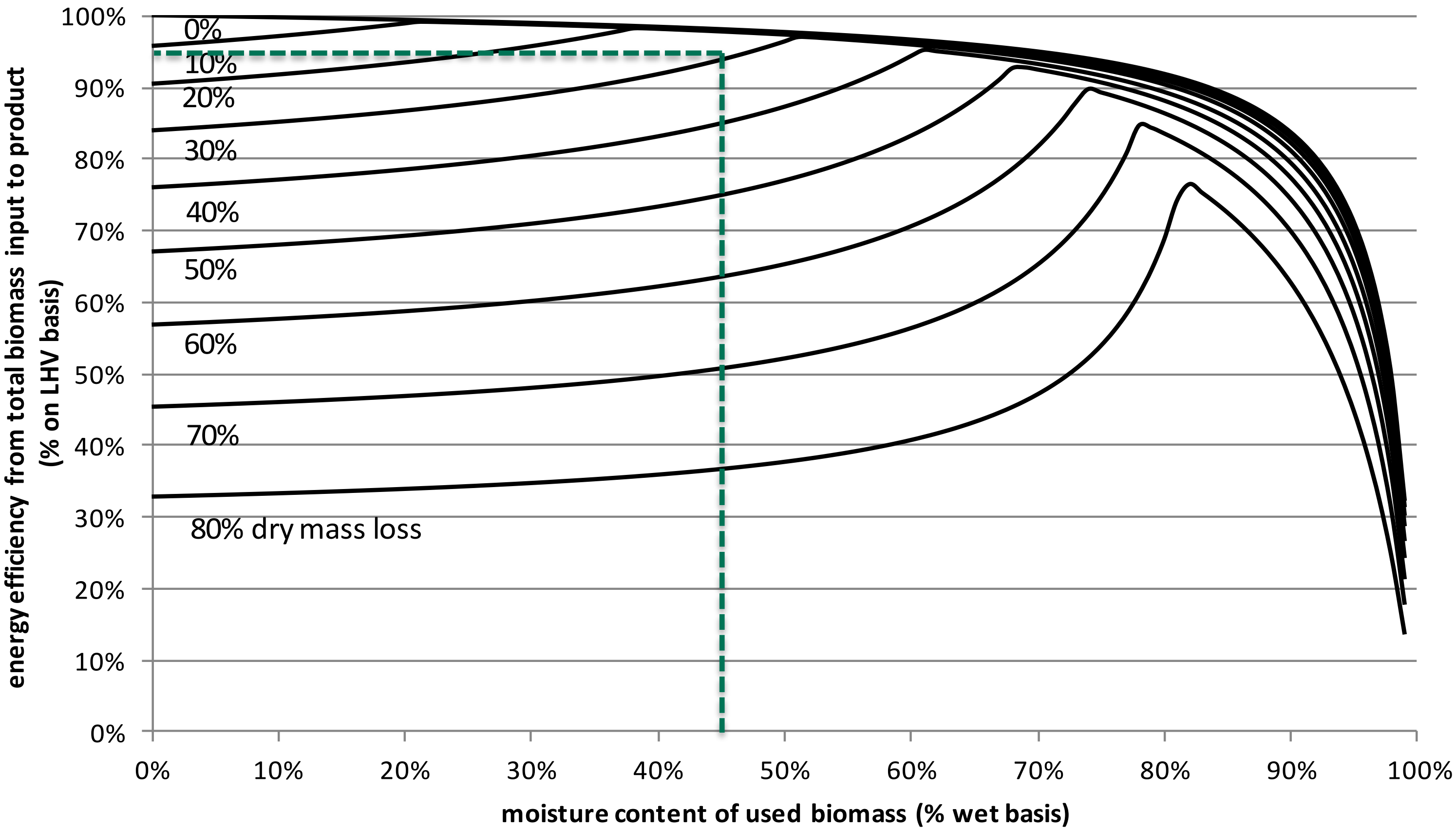
1. Volumetric energy densification brings significant cost reductions in transport and handling
2. Broader feedstock basis - geographically + types of raw material
3. Limited or no biodegradation of product when stored
4. Large variety of applications
5. Reduces CAPEX&OPEX at end user – Immediate use 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

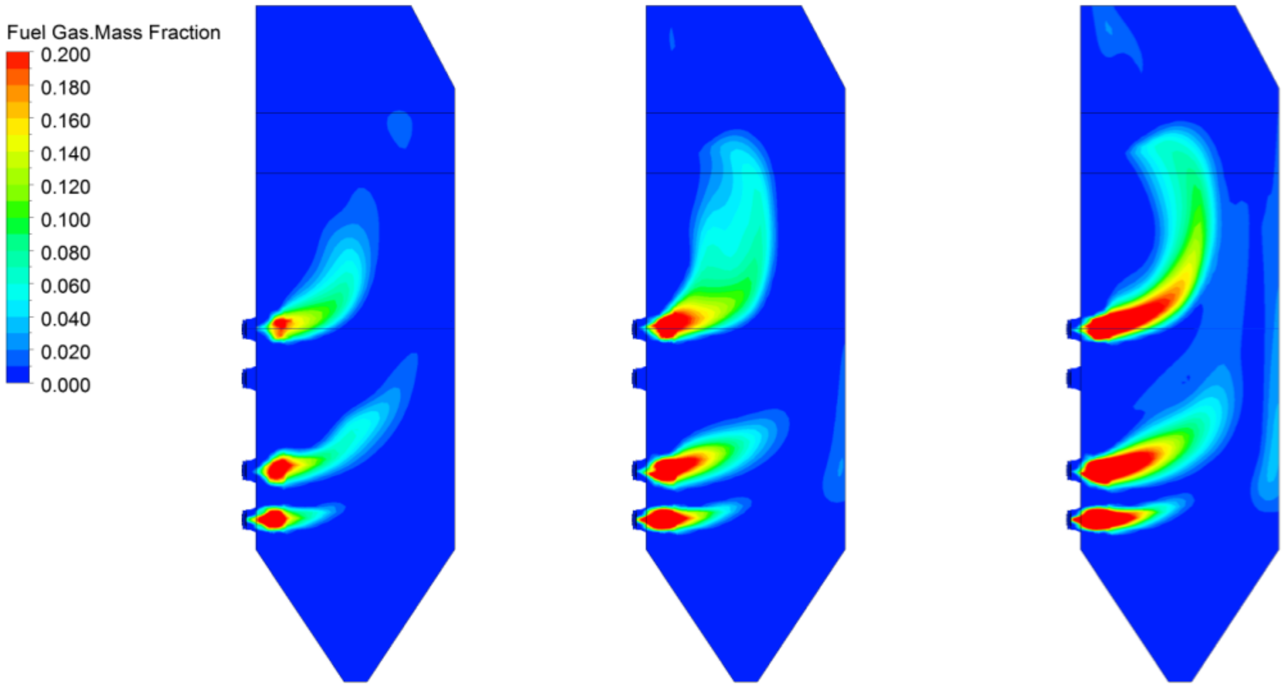
Thermal energy efficiency can easily be over 90% for 30% dry mass loss



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 selectively go down)

Flame shape in a PC boiler



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

Source: Koppejan et.al., Extrapolation of co-firing results to large scale boilers using CFD calculations, SECTOR D7.8, 2014

Status of commercialisation

Marcel CREMERS, PhD

Senior Consultant, Green Thermal Power
DNV GL - Energy

Current situation – available production capacity

Available installed capacity 100-250 ktons/y (facilities > 5 ktons/y)

Typical demonstration scale facility is 3-5 t/h (25-40 ktons/year)

Most built in 2010-2014

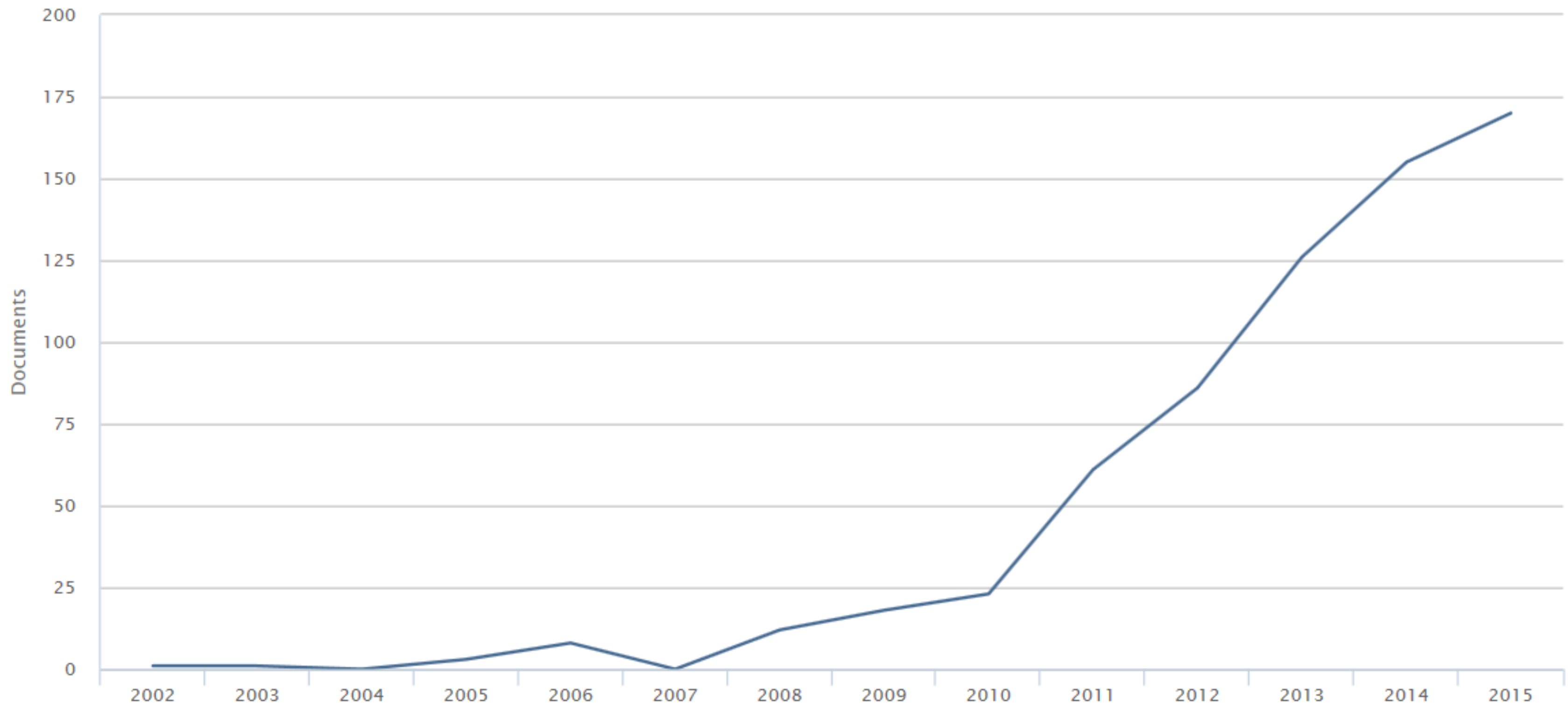
Few plants currently operational due to market conditions

Interviews (2014): Progress rating 5.7 out of 10

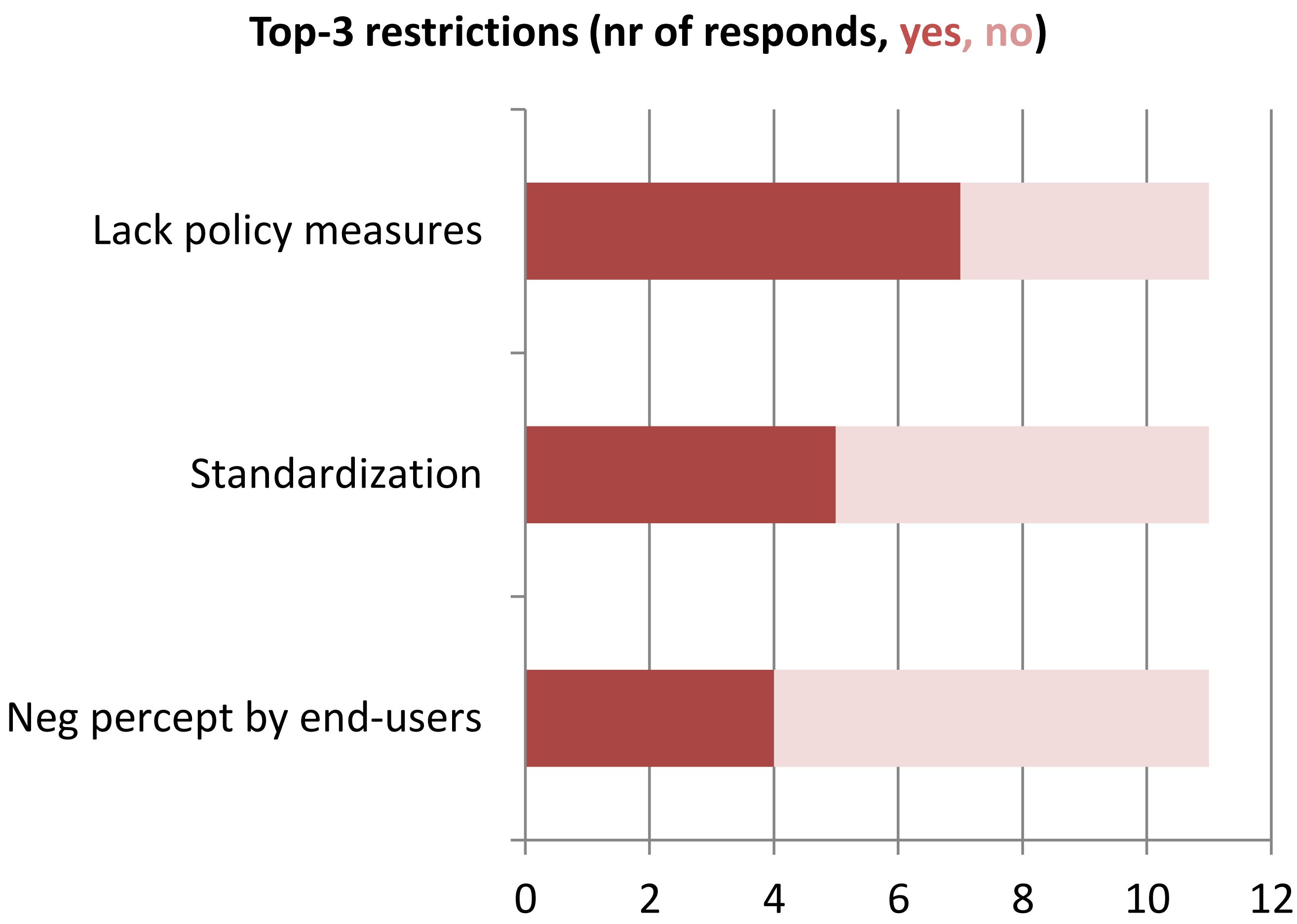
Status of torrefaction initiatives as of early 2015

Developer	Technology	Location(s)	Production capacity (ton/a)	Scale and status Pilot scale: 0.05- 0.55 tph Demo scale: 0.5- 2 tph Commercial scale: > 2tph	Full integration (pre-treatment, torrefaction, combustion, heat cycle, densification)	Status
Clean Electricity Generation (UK)	Oscillating bed	Derby (UK)	30,000	Commercial scale	Yes	Available/operational
Horizon Bioenergy (NL)	Oscillating belt conveyor	Steenwijk (NL)	45,000	Commercial scale	Yes	Dismantled
Solvay (FR) / New Biomass Energy (USA)	Screw reactor	Quitman (USA/MS)	80,000	Commercial scale	Yes	Available/operational
Topell Energy (NL)	Fluidised bed	Duiven (NL)	60,000	Commercial scale	Yes	Mothballed
Torr-Coal B.V. (NL)	Rotary drum	Dilsen-Stokkem (BE)	30,000	Commercial scale	Yes	Available/operational
Airex (CAN/QC)	Cyclonic bed	Bécancour (CAN/QC)	16,000	Demonstration scale		Available/operational
Agri-Tech Producers LLC (USA/SC)	Screw reactor	Allendale (USA/SC)	13,000	Demonstration scale	Yes	Scheduled to be built
Andritz (AT)	Rotary drum	Frohnleiten (AT)	10,000	Demonstration scale	Yes	Out-of-service
Andritz (DK) / ECN (NL)	Moving bed	Stenderup (DK)	10,000	Demonstration scale		Unknown
BioEndev (SWE)	Dedicated screw reactor	Holmsund, Umea (SWE)	16,000	Demonstration scale	Yes	Available (2015)
CMI NESA (BE)	Multiple hearth	Seraing (BE)	Undefined	Demonstration scale		Unknown
Earth Care Products (USA)	Rotary drum	Independence (USA/KS)	20,000	Demonstration scale		Available/operational
Grupo Lantec (SP)	Moving bed	Urnieta (SP)	20,000	Demonstration scale		Unknown
Integro Earth Fuels, LLC (USA)	Multiple hearth	Greenville (USA/SC)	11,000	Demonstration scale		Unknown
LMK Energy (FR)	Moving bed	Mazingarbe (FR)	20,000	Demonstration scale		Unknown
River Basin Energy (USA)	Undefined	Laramie (USA/WY)	Undefined	Demonstration scale		Available/operational
Teal Sales Inc (USA)	Rotary drum	White Castle (USA/LA)	15,000	Demonstration scale		Available/operational
Torrec (FI)	Moving bed	Mikkeli (FI)	10,000	Demonstration scale		Available/operational
Agri-Tech Producers LLC (US/SC)	Screw reactor	Raleigh (USA/NC)	Undefined	Pilot stage		Available/operational
Airex (CAN/QC)	Cyclonic bed	Rouyn-Noranda (CAN/QC)	Undefined	Pilot stage		Available/operational
Airex (CAN/QC)	Cyclonic bed	Trois-Rivières (CAN/QC)	Undefined	Pilot stage		Available/operational
Arigna Fuels (IR)	Screw reactor	County Roscommon (IR)	Undefined	Pilot stage		Available/operational
CENER (SP)	Rotary drum	Aoiz (SP)	Undefined	Pilot scale		Available/operational
Terra Green Energy (USA)	Multiple hearth	McKean County (USA/PA)	Undefined	Pilot scale		Available/operational
Wyssmont (USA)	Multiple hearth	Fort Lee (USA/NJ)	Undefined	Pilot scale		Unknown
CEA (FR)	Multiple hearth	Paris (FR)	Undefined	Laboratory scale		Available/operational
Rotawave, Ltd. (UK)	Microwave	Chester (UK)	Undefined	Laboratory scale		Unknown
Bio Energy Development & Production (CAN)	Fluidised bed	Nova Scotia (CAN/NS)	Undefined	Unknown		Unknown

Current situation - research



Restrictions



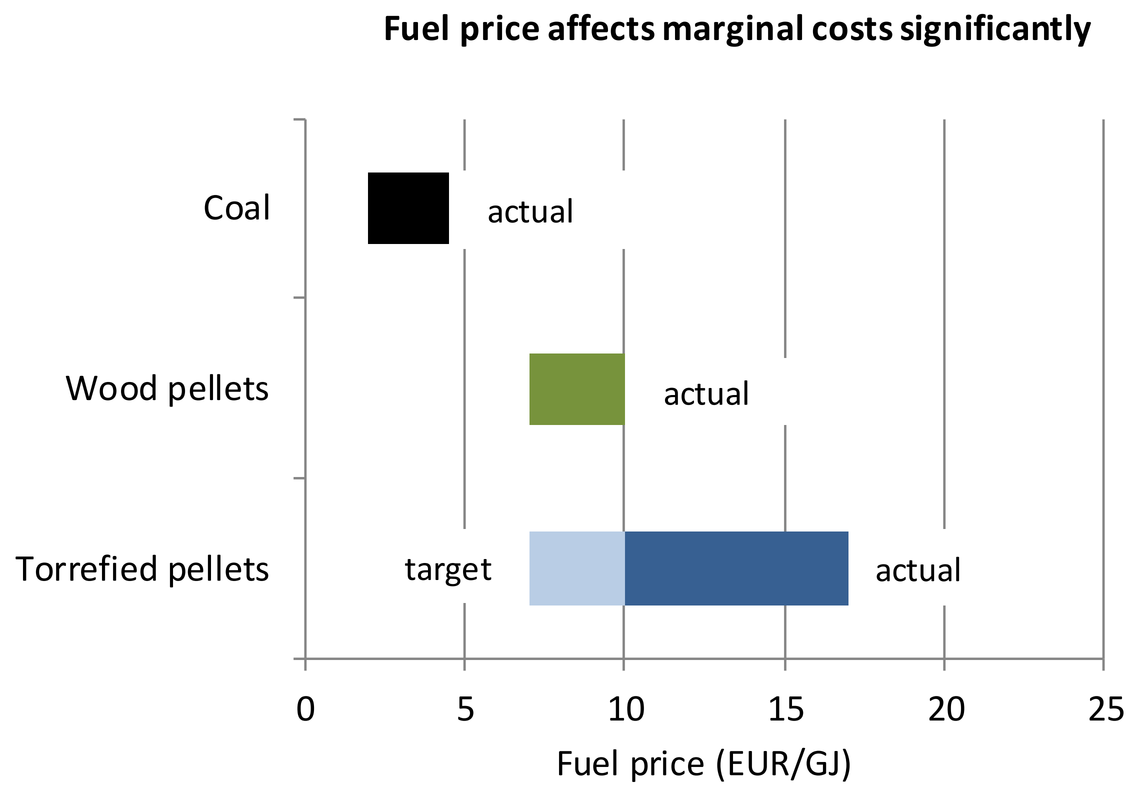
Policy measures

Primary instruments

- Innovation subsidy
- Renewable energy subsidy

Cost recovery gap

- Price parity with coal (fuel, CO_2)
- Competition with wood pellets



Standardization

- Necessity for trading
- Quality specification
- REACH
- MSDS
- Sustainability (GHG)


DRAFT INTERNATIONAL STANDARD
ISO/DIS 17225-8

ISO/TC **238** Secretariat: **SIS**

Voting begins on: **2016-01-14** Voting terminates on: **2016-04-14**

Solid biofuels — Fuel specifications and classes —

Part 8:
Graded thermally treated and densified biomass fuels

Biocombustibles solides — Classes et spécifications des combustibles

ICS: 27.190; 75.160.10

PREVIEW

THIS DOCUMENT IS A DRAFT CIRCULATED FOR COMMENT AND APPROVAL. IT IS THEREFORE SUBJECT TO CHANGE AND MAY NOT BE REFERRED TO AS AN INTERNATIONAL STANDARD UNTIL PUBLISHED AS SUCH.

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ISO/CEN PARALLEL PROCESSING

This draft has been developed within the International Organization for Standardization (ISO), and processed under the **ISO lead** mode of collaboration as defined in the Vienna Agreement.

This draft is hereby submitted to the ISO member bodies and to the CEN member bodies for a parallel five month enquiry.

Should this draft be accepted, a final draft, established on the basis of comments received, will be submitted to a parallel two-month approval vote in ISO and formal vote in CEN.

To expedite distribution, this document is circulated as received from the committee secretariat. ISO Central Secretariat work of editing and text composition will be undertaken at publication stage.

ISO

Reference number
ISO/DIS 17225-8:2015(E)

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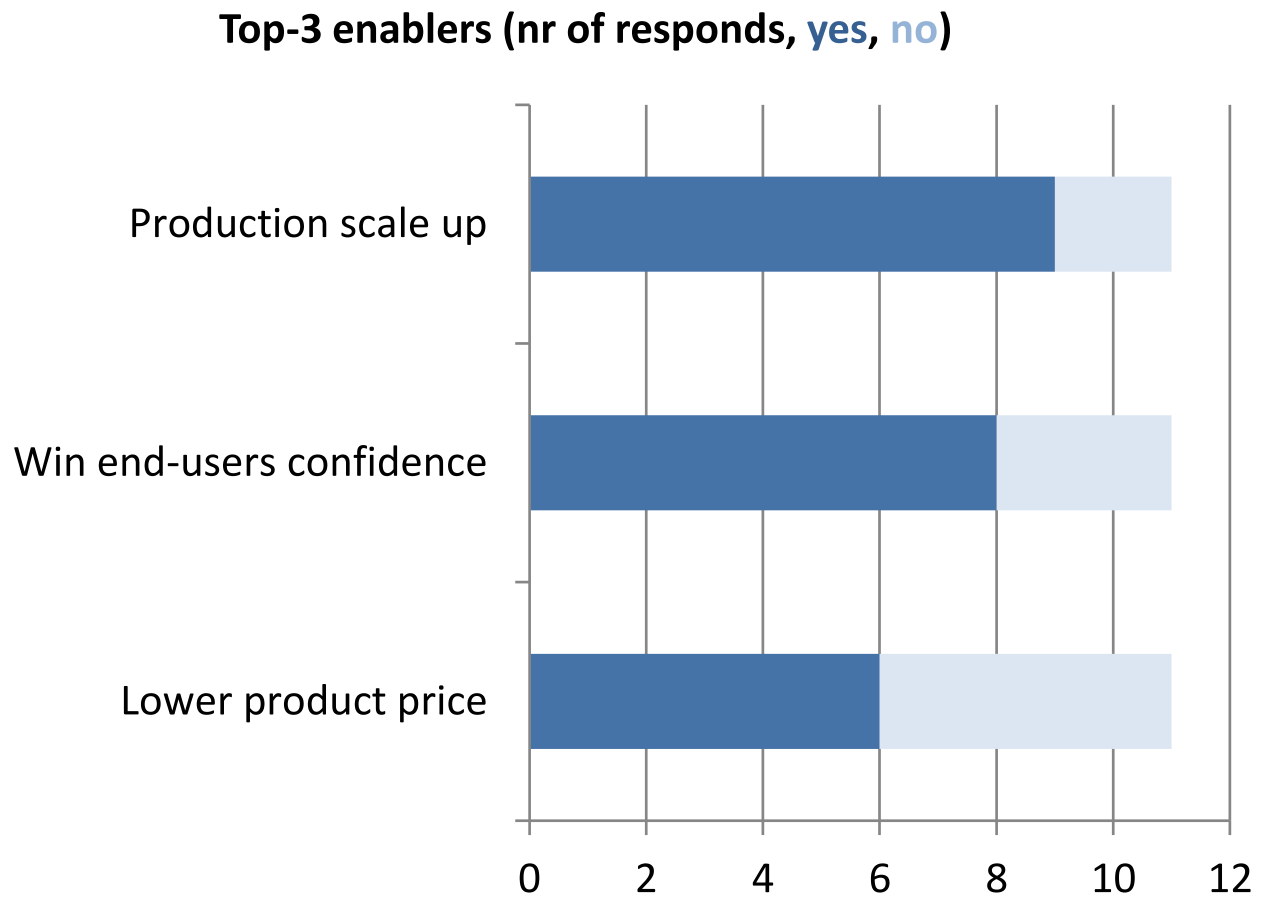
Negative perception by end-users

2003-2007	2008-2012	2012-2015
Co-firing commercial	New initiatives	IBTC
Lab scale (ECN)	Demo-scale	Product quality
Promising results	Huge claims	Availability
	Financial crisis	Off-take contracts
	Focus on torrefaction	Wood pellet market
	Process control	chicken and egg

Enablers



Top-3 enablers (nr of responds, yes, no)
Production scale up
Win end-users confidence
Lower product price
0
2
4
6
8
10
12

Production scale up

Demand	Production
600 MWe coal plant 10% co-firing 6000 eoh	Demo plant 25-40 ktons/y Partly utilized
150 ktons/y torrefied pellets	Global production capacity < 150 ktons/y
	Wood pellets 50-200 ktons/y per facility

Picture of balance: openclipart, designer Enhy

Win end-users confidence

- Identify (niche) markets: developing the chain
- Realistic promises
- Quality assurance
- Health and safety (pros and cons)
- Tradability & standardization

Bring down price

Price comparable with wood pellets, what should be feasible?

Commercial (target) price in USD/GJ

	Wood pellets	Torrefied pellets	Savings
Cost of biomass	4,28	4,28	0,00
Cost of electricity	0,60	0,74	0,14
Cost of labor	0,47	0,47	0,00
Financial costs	1,01	1,49	0,48
Other costs	0,40	0,43	0,03
Cost price at production site	6,76	7,41	0,65
Inland logistics from the plant to the port	1,12	0,57	-0,55
Deep sea shipment	2,04	1,28	-0,76
Cost price delivery harbor	9,92	9,26	-0,66

Reference: IEA Bioenergy task 32 status report (2012)

Breaking chicken-egg problem

- Specific offset markets (e.g. energy, (steel)industry, bio-economy)
- Develop the chain
- Alternative feedstock types

Figure: The Torr-Coal plant in Dilsen-Stokkem (Belgium). Courtesy Torr-Coal

<u>Example (in development):</u>

Arsari bio-based economy project REBUILD

Kalimantan, Indonesia

JV of

- Arsari Enviro Industri, and
- A.Hak Renewable Energy

Torrefaction technology supplier

- Torr-Coal International

https://www.youtube.com/watch?v=srqq6ox2wkw

Implications on international trade

Michael Wild

President, International Biomass Torrefaction Council

Products available today

Source: Andritz AG

Torrefaction Implementation Indicator

Torgas Handling		done
Torgas Utilisation		done
Continuous torrefaction		done
Predictability and consistency of product		for many feedstocks done
Densification		in optimisation
Feedstock flexibility		mostly done
Safety in plant		done
Indoor storage		done
Outdoor storage		in optimisation
Standardisation of product		ISO in progress
Safety along supply chain		in optimisation
Trade Registrations and Permissions		active in progress
Co-firing trials		done
Co-firing burn tests		in progress
Co-firing full scale		In progress
Heat application trials		in progress
Heat application acceptance		open

Conditions for trade

- Will character of torrefied fuel permit using existing logistical infrastructure?
- Is there proof of non hazardousness or are special safety measures to be advised?
- How about standardization and trading documents?
- Is there demand?
  - Where is torrefied biomass a proven fuel
  - Where are reasonable potentials seen

Water uptake

ACB - Weather test prelim. results briquettes

Method:

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

Sample 1

Sample 2

21 rainfalls have been documented during storage time, 3 rainfalls with > 20 mm/m^2

Sample	Diameter [mm]	TG [%]	DS [%]	Water uptake [%]	Durability [%]	Density [kg/dm³]
Original Sample	71	25	97%	2	96	1,14
Sample 1	71	25	92%	1	84	1,14
Sample 2	71	25	93%	1	91	1,16

Small-scale outdoor storage

- 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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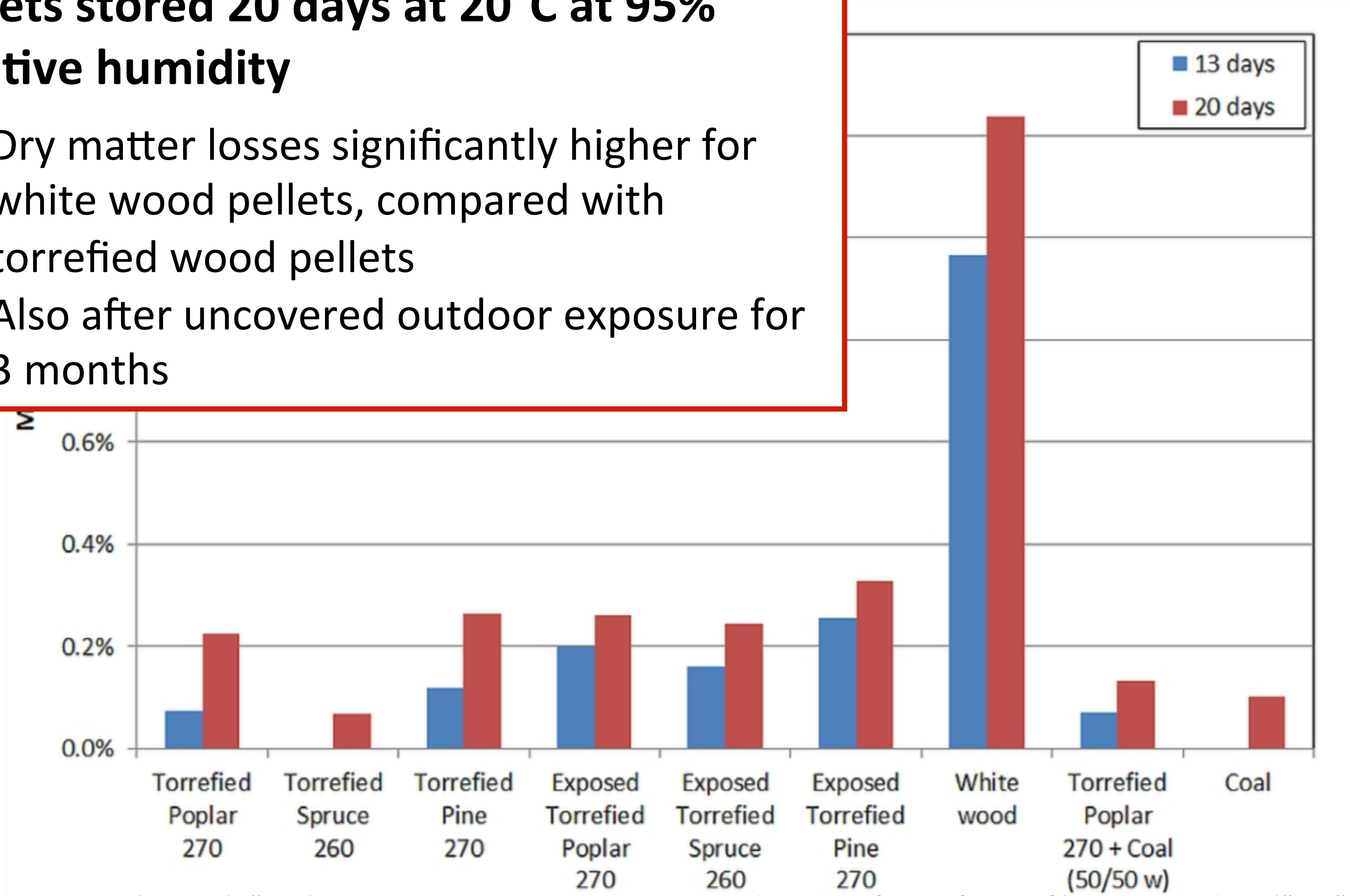
Biological Degradation

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

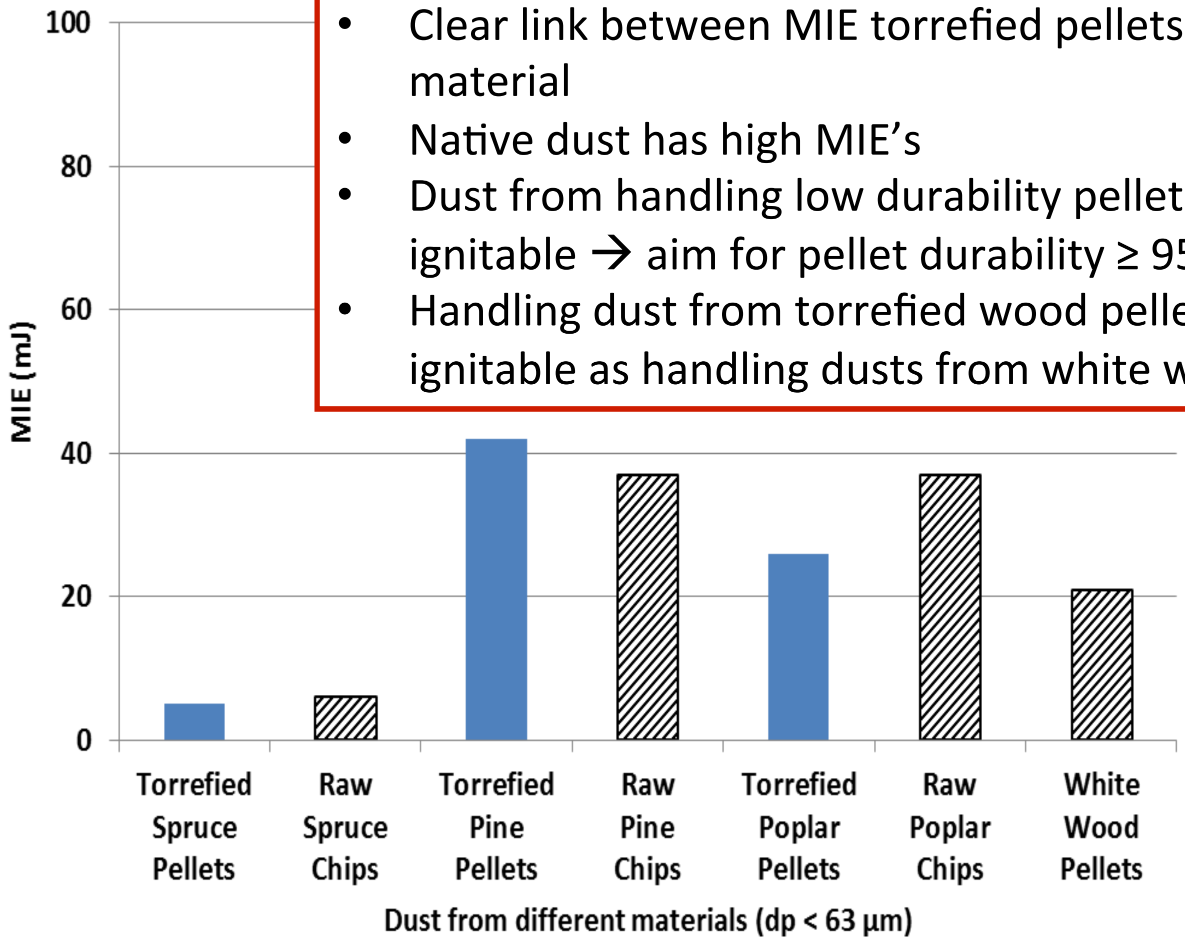
- Dry matter losses significantly higher for white wood pellets, compared with torrefied wood pellets
- Also after uncovered outdoor exposure for 3 months



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)

- 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

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Leaching/Eluation, Ecotoxidity

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 38412-31

Source: Torrlog

Quality - Standardisation

- **ISO 17225:** Solid biofuels – Fuel specifications and classes – Part 8: Graded thermally treated and densified biomass fuels

Technical Specification in Q4 2016

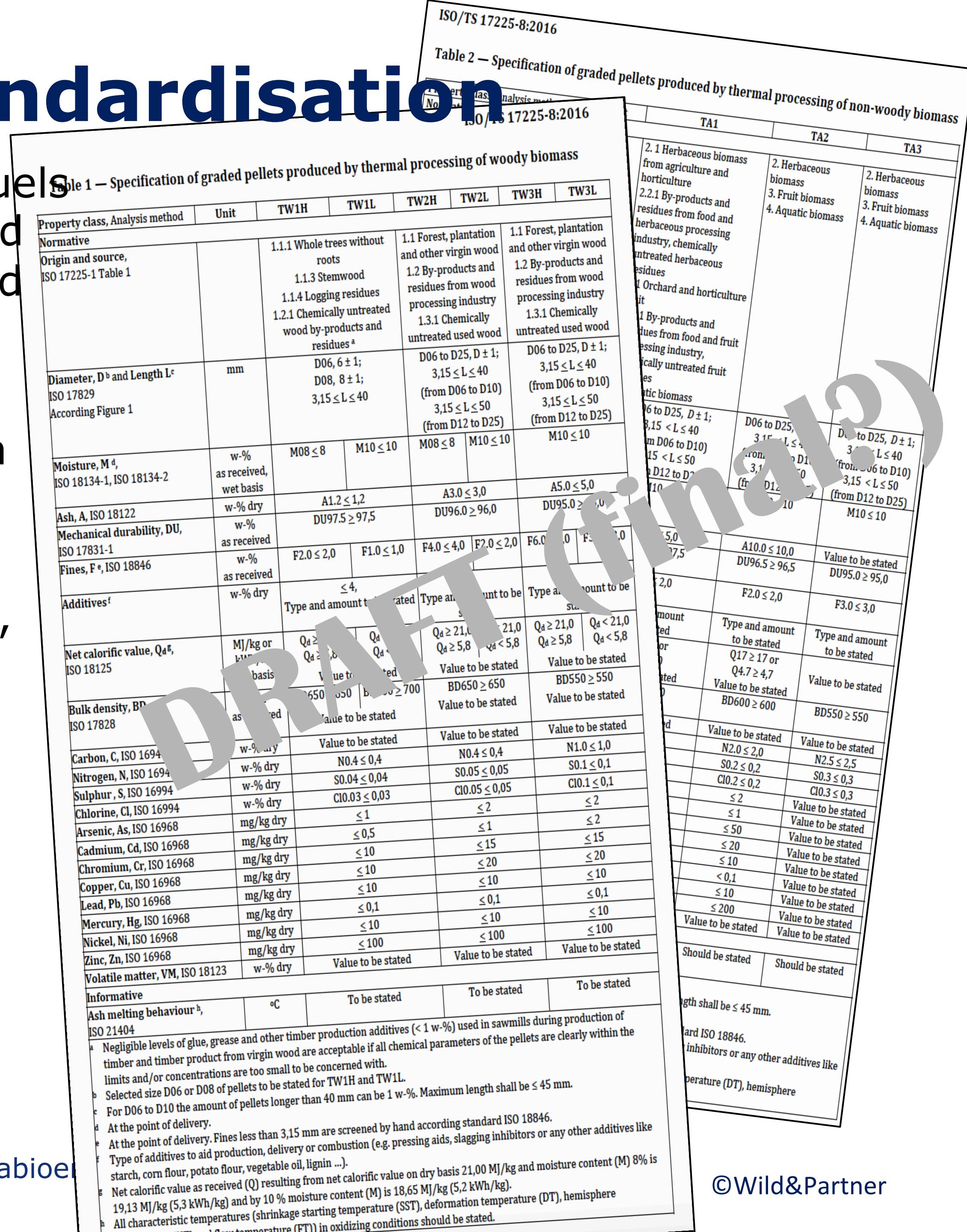
Different Classes (NCV, Durability, Bulk Density, Volatile Matter etc.)

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 ≥ [illegible]	
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 [illegible]	F[illegible]
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 [illegible] basis	Q_d [illegible]	Q_d [illegible]	$Q_d \geq 21,0$ $Q_d \geq 5,8$	$Q_d < 21,0$ $Q_d < 5,8$	$Q_d \geq 21,0$ $Q_d \geq 5,8$	$Q_d < 21,0$ $Q_d < 5,8$
		Value to be stated		Value to be stated		Value to be stated	
Bulk density, BD, ISO 17828	[illegible]	BD[illegible]650 ≥ 650	BD[illegible] ≥ 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 [illegible] 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

	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 [illegible] Orchard and horticulture [illegible] By-products and [illegible] from food and fruit [illegible] industry, [illegible] untreated fruit [illegible] biomass	2. Herbaceous biomass 3. Fruit biomass 4. Aquatic biomass	2. Herbaceous biomass 3. Fruit biomass 4. Aquatic biomass

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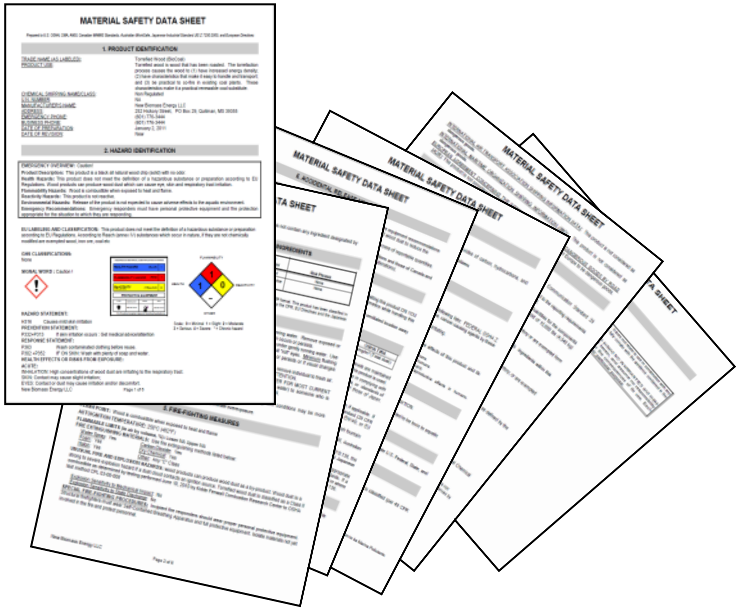
Broadening Feedstock Basis

- **ISO 17225 TS does define product classes derived from wood and product classes from non woody biomass**
- **Torrefaction is clearly seen as door opener to the use of by-products from a wide range of agro food industries or/and feedstock from energy plantation such as grasses, fast growing**
- **By this torrefaction is addressing the key cost component in a bioenery value chain, the feedstock costs and can bring this down substantially.**
- **This can also be the starting point for new value chains into Chemical Industry, torrefaction forming first part of raw material processing into high value product lines**

Documentation, Permissions and Registrations

- MSDS with SECTOR
- REACH
  - Substance Information
  - Exchange Forum "SIEF"
- Working on IMSBC
- All testing to date results in: equal or superior to wood pellets

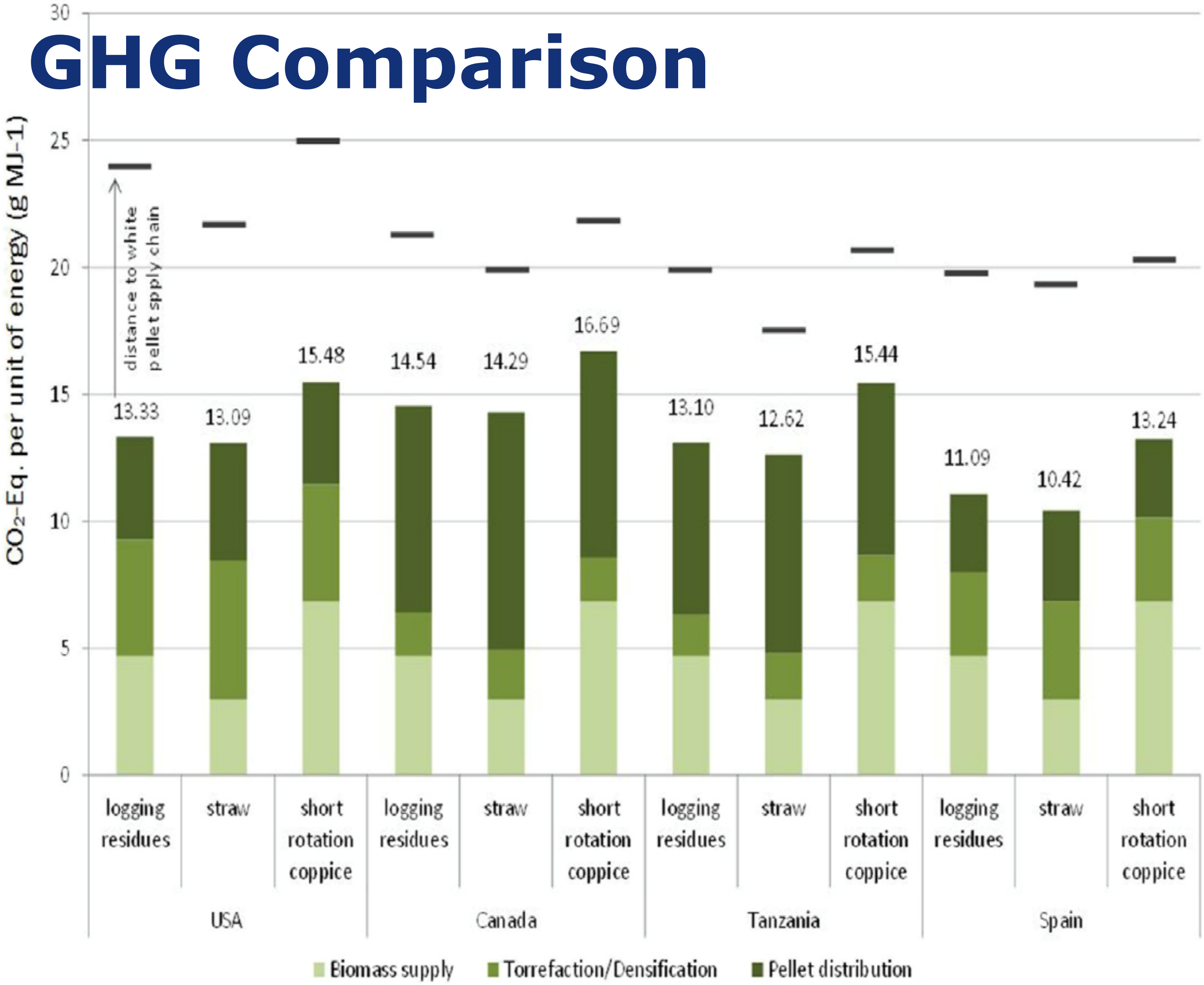


IMO testing

- IMO 4.1 flammability test: not flammable
- IMO 4.2 self heating test: No self heating properties
- Consequently:

  Torrefied material does not need to be classified as flammable solid material or as a self heating substance

GHG Comparison



Source: D. Thrän, DBFZ

Topell Energy

Strictly private & confidenti

Succesfull large scale co-firing test proves benefits of Topell Energy's torrefied pellets

Background on co-firing test	Test results
• Successful large scale co-firing test in Q4 2013 • Partners included ECN and utility companies RWE/Essent, Vattenfall/Nuon and GDF SUEZ • Total of 2,300 tons were co-fired at a 5% - 25% co-firing rate(1) at the Amer power plant of RWE/Essent in the Netherlands	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

RWE The energy to lead · NUON VATTENFALL · GDF SUEZ · ECN

RWE/Essent AMER-9 experience*

- Consortium:Topell, Essent, NUON, GdF Suez, ECN as part of Dutch TKI Pre-treatment Project
- Maximum 25 wt% co-milling on weight basis; 5 wt% co-firing
- 2300 tons of Topell torrefied pellets during November & December '13
- Observations: No significant issues
- ECN conducted lab-scale characterisation of pellets and provided consultancy to mitigate risks during commercial operation

* Source: Press release Topell/Essent, Feb '14

NUON/Vattenfall Buggenum experience*

- Maximum 70% co-gasification on energy basis achieved at 90% nominal load without major modifications
- 1200 tons of torrefied pellets during 24 hours trial
- Observations:
  - Relatively low durability led to significant dust formation
  - Low durability disadvantageous during outdoor storage
  - Low Minimum Ignition Energy (MIE)
- ECN conducted lab-scale test programme to characterise pellets and provided consultancy to mitigate risks during commercial operation

* Source: N. Padban, Central European Biomass Conference, Jan '14, Graz; 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

Non Power Applications

Steel Industry	Replacement of coking coal Pulverized coal Fossil fuels
Chemical/Petrochemical	Gasification Chemicals from Biomass
Pulp&Paper	Use in lime sludge kilns Coal substitute for Energy
Non Metallic Minerals	Substitution of conventional fuels in kilns

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Non Power Applications by Sector

Industries	Biomass use as of 2012 and percentage of total consumption	Prediction for 2025	
		Biomass	Torrefied biomass
Iron and steel	0.15 EJ (1%)	2.0 %	0.4 % (60 PJ)
Chemical and petrochemical	0.06 EJ (1%)	1.5 %	Low
Pulp and paper	2.20 EJ (36%)	38–40 %	1.5 % (90 PJ)
Non-metallic minerals (glass, ceramic, cement)	0.40 EJ (2%)	3.0–3.5 %	0.8 % (150 PJ)
Transport equipment and fabricated metal products, machinery and equipment	0 PJ (0%)	0.1 %	Low
Total	2.80 EJ (0.7 %)	30 %	10 % (300 PJ)

Non power applications by region

Region	Current industrial biomass use and proportion of the total biomass consumption for energy (IEA)	Prediction of consumption by industry in 2025		
		Biomass	Torrefied biomass	Most attractive industries for torrefied-biomass use
EU-28	1 EJ (9%)	13%	5–10%	Pulp and paper, non-metallic minerals
Africa	0.8 EJ (32%)	35%	Low	
Asia	2 EJ (5%)	7%	0.5–1%	Iron and steel, pulp and paper
Canada	0.3 EJ (10%)	13%	2–3%	Pulp and paper, non-metallic minerals
US	1 EJ (11%)	14%	2–3%	Non-metallic minerals, pulp and paper
Australia	0.1 EJ (11%)	15%	1–2%	Pulp and paper
Brazil	1.5 EJ (42%)	43%	1–1.5%	Iron and steel, pulp and paper, non-metallic minerals
Japan	0.1 EJ (3%)	3.5%	0.5–1%	Non-metallic minerals, pulp and paper

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Where we are today

- Quality according ISO TS
- Handling & Storage advantage in logistics verified
- Cost reductions shown
- Acceptability and advantages in co-firing verified by utilities
- Non Woody Biomass successfully tested
- Product is available
- Several technologies
- More than 1 producer
- Final prices to be calculated on basis of offtake, but surely competitive

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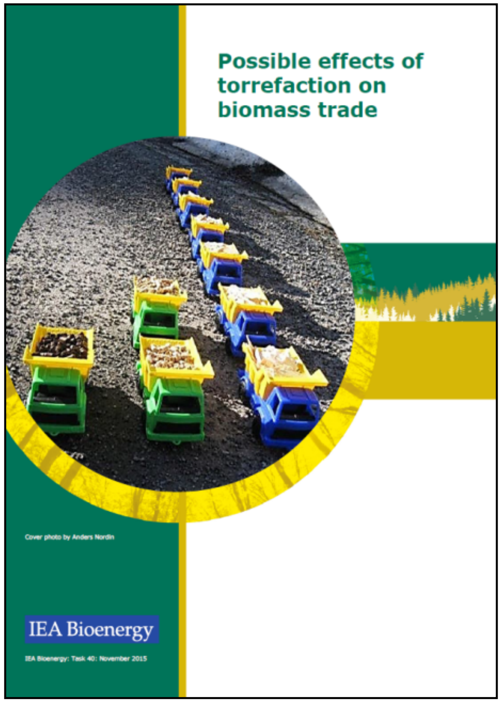

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Questions?

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