SECTOR

Production of solid sustainable energy carriers from biomass by means of torrefaction

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SECTOR

Production of solid sustainable energy carriers from biomass by means of torrefaction

5th International Freiberg Conference on IGCC & XtL

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www.ecn.nl

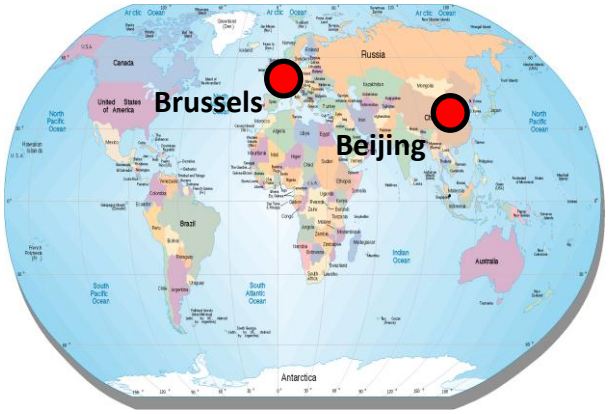
Presentation overview

- Introduction to the Energy research Centre of the Netherlands (ECN)
  - General mission
  - Core activities in biomass
- Torrefaction
  - Background & drivers
  - Status torrefaction technology & product quality
- The SECTOR project
  - Facts
  - Scope
  - Objectives
  - Torrefaction technologies considered
  - Structure

Energy research Centre of the Netherlands (ECN)

- Dedicated to Sustainable Energy Innovation
  With and for the market, ECN develops knowledge and technology that enable a transition to a sustainable energy system

- Core activities in biomass
  Sustainable energy technology development
  R&D services to industry
  Feasibility studies, system ^technology assessments




Biomass


Solar


Wind


Energy efficiency


Policy studies

Biomass – a difficult energy source

- In view of:
  - Logistics (handling, transport and feeding)
  - End-use (combustion, gasification, chemical processing)

- Difficult properties are:
  - Low energy density (LHV_{ar} = 10-17 $^{MJ}/_{kg}$)
  - Hydrophilic
  - Vulnerable to biodegradation
  - Tenacious & fibrous (grinding difficult)
  - Poor “flowability”
  - Heterogeneous

Torrefaction – the drivers

Woody biomass

Agricultural residues

Friable and less fibrous
18 - 24 MJ/kg (LHV, ar)
More hydrophobic
Preserved
More homogeneous

Superior fuel properties:

- Transport, handling, storage
- **Milling, feeding**
- **Gasification, combustion**
- Broad feedstock range
- Commodity fuel

Mixed waste

Torrefaction and pulverisation

Fuel powder

Pelletisation

Fuel pellets

Tenacious and fibrous
7 - 12 MJ/kg (LHV, ar)
Hydrophilic
Vulnerable to biodegradation
Heterogeneous

Bulk density 650-800 kg/m^3
Bulk energy density 12-19 GJ/m^3

Product quality

Sources: ECN (table, fig.1, 3) Pixelio (fig. 2, 5) OFI (fig. 4)	Wood chips	Wood pellets	Torrefied wood pellets	Charcoal	Coal
Moisture content (wt%)	30 - 55	7 - 10	1 - 5	1 - 5	10 - 15
Calorific value (LHV, MJ/kg)	7 - 12	15 - 17	18 – 24	30 - 32	23 - 28
Volatile matter (wt% db)	75 - 84	75 - 84	55 - 70	10 - 12	15 - 30
Fixed carbon (wt% db)	16 - 25	16 - 25	22 - 35	85 - 87	50 - 55
Bulk density (kg/l)	0.2 - 0.3	0.55 - 0.65	0.65 - 0.80	0.18 - 0.24	0.80 - 0.85
Vol. energy density (GJ/m^3)	1.4 - 3.6	8 - 11	12 - 19	5.4 - 7.7	18 - 24
Hygroscopic properties	Hydrophilic	Hydrophilic	Moderately Hydrophobic	Hydrophobic	Hydrophobic
Biological degradation	Fast	Medium	Slow	None	None
Milling requirements	Special	Special	Standard	Standard	Standard
Product consistency	Limited	High	High	High	High
Transport cost	High	Medium	Low	Medium	Low

Abbreviations:
db = dry basis
LHV =Lower Heating Value





Torrefaction technology

New Biomass Energy

Stramproy Green

Thermya

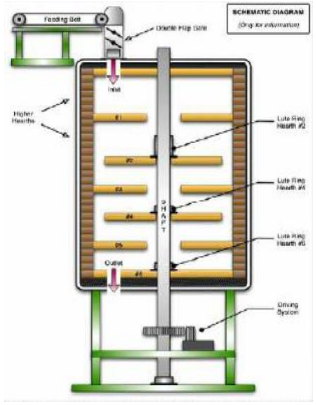
EU developments

Topell Energy

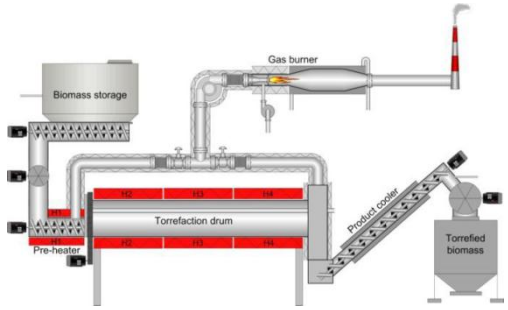
Torrcoal

Torkapparater

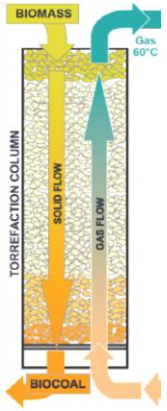
Torrefaction technology



Multiple hearth furnace

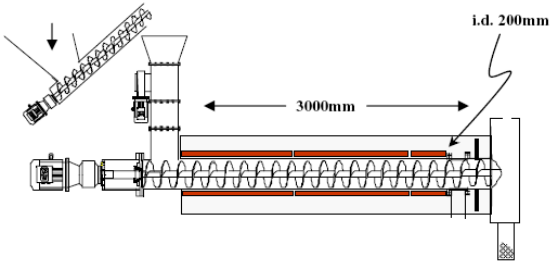


Rotary drum reactor

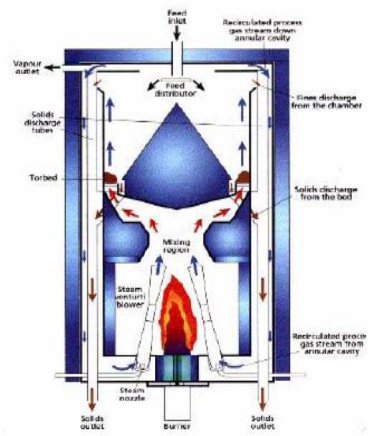


Moving bed reactor

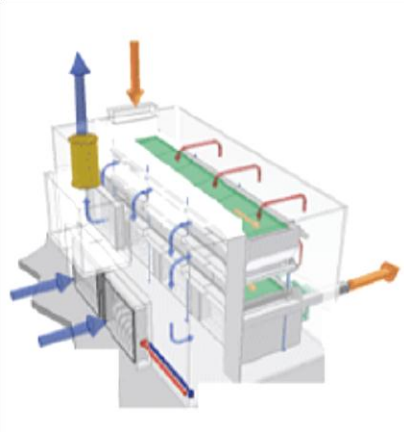
Source: KEMA



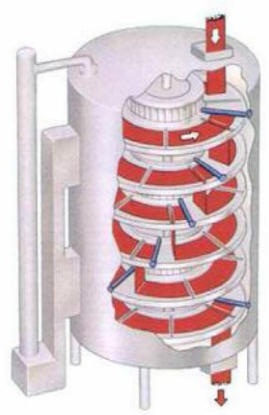
Screw conveyor reactor



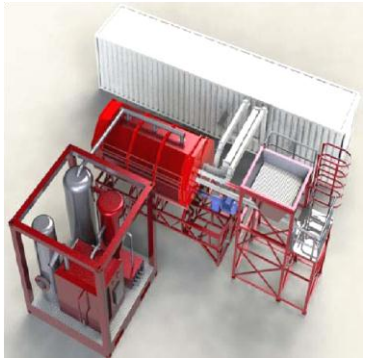
Torbed reactor



Oscillating belt reactor



TurboDryer



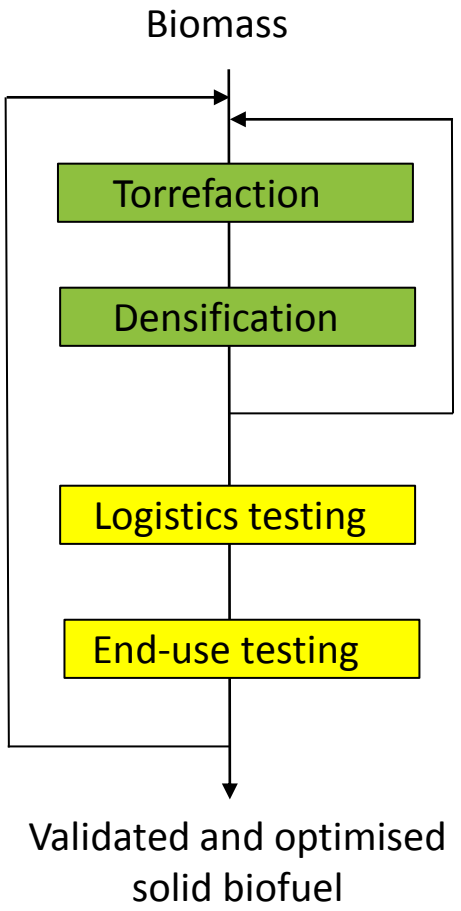
Microwave reactor

ECN 50 kg/h torrefaction pilot plant
(Since February 2008)

Andritz-ECN Demo Plant
(March 2012)

The SECTOR project – Product quality optimisation

- Pilot, demo and first commercial plants produce kg-tonne scale batches allowing representative logistics and end-use performance testing by industry
- Many coal-fired power plants want to be early adaptors and show interest in conducting co-firing trials (e.g., RWE, Vattenfall)
- Product quality optimisation requires a systematic iterative approach (2 iterative loops)
- For this purpose, European torrefaction developers, combustion and gasification technology providers and end-users have joined forces in the EU-FP7 project SECTOR



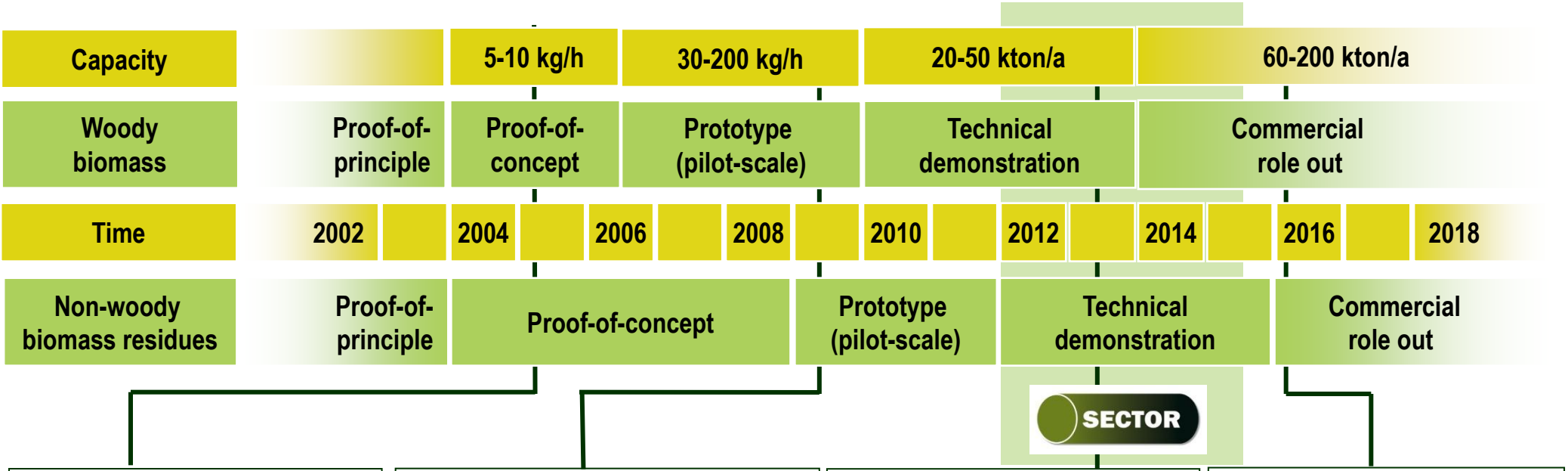
The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 282826.

SECTOR

Production of Solid Sustainable Energy Carriers from Biomass by means of Torrefaction

- Collaborative project: SECTOR
- Project start: 01.01.2012
- Duration: 42 months
- Total budget: 10 MEuro
- Participants: 21 from 9 EU-countries + industrial advisory group
- Coordinator: DBFZ (supported by ECN, ofi)

Torrefaction and densification technology roadmap



Proof-of-concept
- Experimentally based process designs
- Technology identification
- **Knowledge base**
- Experimental infrastructure
- Economic evaluations full-scale (study about 30%)
- Set-up pilot phase development

Prototype development (pilot-scale evaluation)
- Pilot plants / prototype technology
- Demo technical feasibility
- **Process & product characterization (design)**
- Economic evaluations full-scale (preliminary ca. 20%)
- Business plan(s) (technical demo)

Technical demonstration
- Demonstration plants
- **Technical optimization**
- **Product applications (logistics & end-use)**
- Economic evaluations full-scale (definite ca. <10%)
- Business plan(s) (commercial operation)

Commercial role out
- Commercial plants
- **Quality control and assurance (product)**
- **Best practice sustainability**
- **Product standardisation**
- Purchase agreements (from energy & chemical sector)

SECTOR objectives

- **Support the market introduction** of torrefaction-based bioenergy carriers as a sustainable commodity solid fuel
- **Further development of torrefaction**-based technologies (up to pilot-plant scale and beyond)
- **Development of specific production recipes**, validated through extensive lab-to-industrial-scale logistics and end-use performance testing
- Development and standardisation of dedicated **analysis and testing methods** for assessment of transport, storage, handling logistics and end-use performance
- Assessment of role of torrefaction-based solid bioenergy carriers in the bioenergy **value chains** and their contribution to development of **bioenergy market in Europe**
- **Full sustainability assessment** of four major torrefaction-based biomass-to-end-use value chains
- **Dissemination** of project results to industry and into international forums (e.g. CEN/ISO, IEA and sustainability round tables)

Logistics, handling and end-use

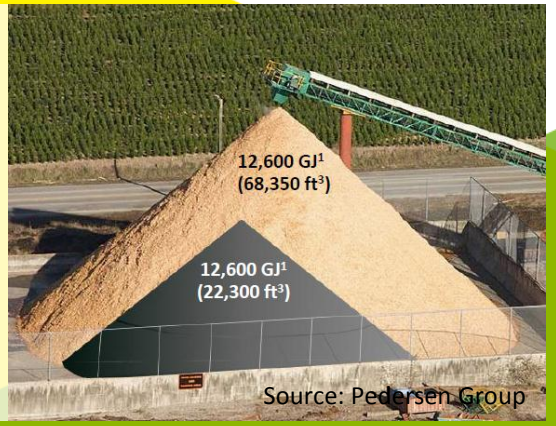
(Co-)gasification

Shipment

Handling

Co-firing

Storage



Grinding & feeding

Pellet boiler

Advantages, disadvantages and challenges

Advantages

- Increased feedstock basis
- High energy density of torrefied products ➲ effective transport
- Reduced water retention force (hydrophobicity)
- Slower biodegradation potential
- Better grindability due to embrittlement
- Decreased costs for handling, storage and transport
- Biomass torrefaction can create new markets and trade flows as a commodity fuel (➲ product standards are needed)

Disadvantages / Challenges

- Dust and dirtiness at handling and transport
  - Safety issues must be assessed
  - Self ignition and spontaneous combustion occurs at 150-170°C
- Explosion hazards increase compared to conventional biomass but probably not in comparison with coal
- Compacting (pellets / briquettes) is more difficult
- Additional fuel properties (e.g. degree of torrefaction, grindability, hydrophobic nature, resistance against biodegradation) and sustainability criteria must be defined ➲ ISO work

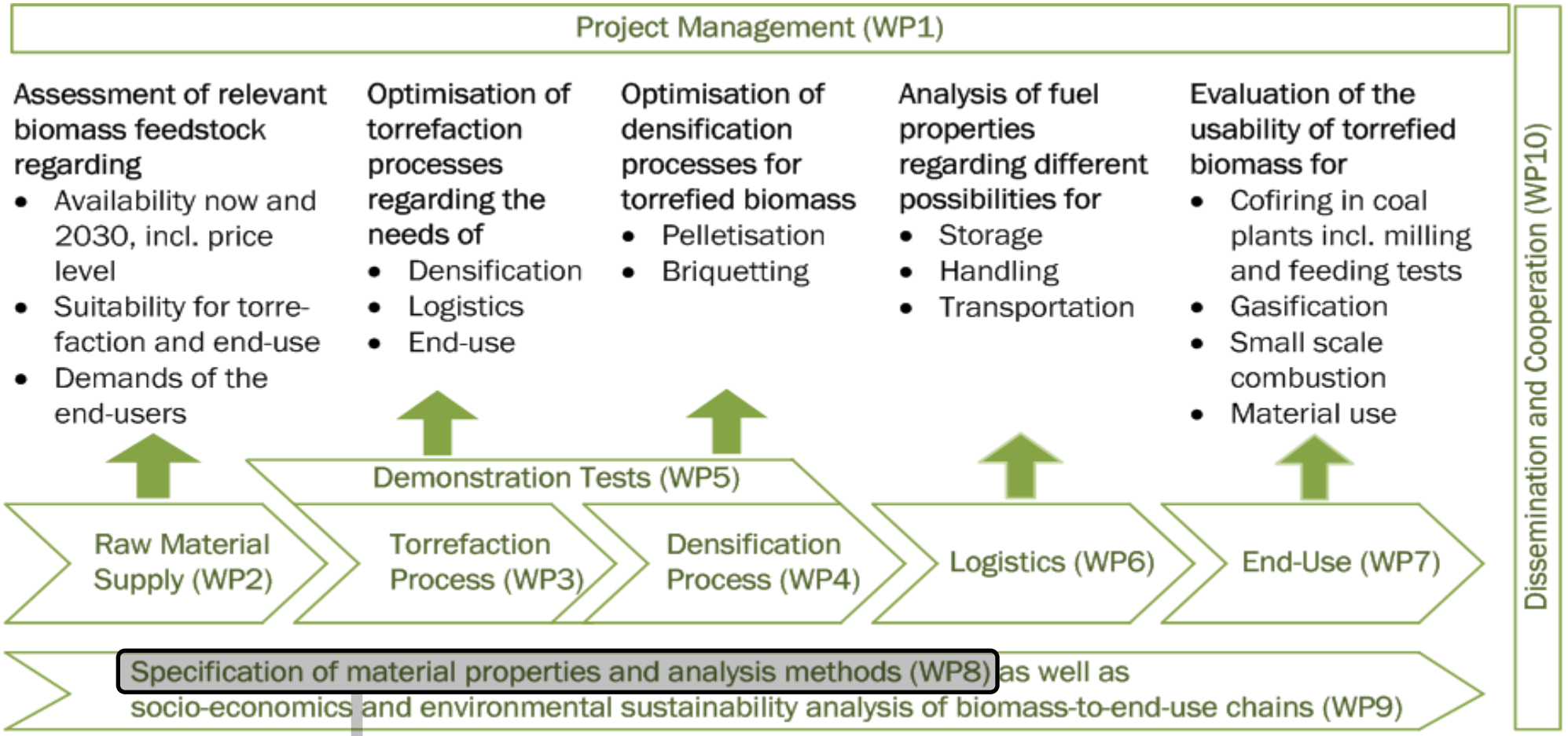
Safety issues

self-heating (chemical oxidation of torrefied wood chips)

Thermometer → **Smoke in 24 Minutes** → **Fire in 32 Minutes**

End of production run on Wednesday → **Fire on Saturday**

SECTOR project structure



Round Robin for validation existing standards (May - Sep 2012)
EN 15103, 15210-1, 14774-2, 14775, 14918, 15289, 15148, 15104, 15290, 15297, CEN/TS 15370-1

Round Robin

Participant	Country	EN 15103 bulk density	EN 15210-1 durability	EN 14774-2 moisture	EN 14775 ash	EN 14918 calorific value	EN 15289 S & Cl	EN 15148 volatiles	EN 15104 CHN	EN 15290 Major	EN 15297 Minor	CEN/TS 15370-1 ash melting
	11	17	15	20	20	19	16	18	16	11	10	10
OFI	A	1	1	1	1	1	1	1	1	1	1	1
Bioenergy 2020+ GmbH	A			1	1	1	1	1		1	1	
GDF-Suez	Be			1	1	1	1	1	1			
CRA-W U13	Be	1	1	1	1	1		1				
TFZ	D	1	1	1	1	1						
Danish Technological Institute	DK	1	1	1	1							
Dong Energy, ENV Lab.	DK	1	1	1	1	1	1	1	1	1	1	
CENER-CIEMAT	Es	1	1	1	1	1		1	1			
Ciemat	Es	1	1	1	1	1	1	1	1	1		1
VTT	FI	1		1	1	1	1	1	1			
ECN	NI			1	1	1	1	1	1	1	1	
TLR International Laboratories	NI	1	1	1	1	1	1	1	1	1	1	1
Laboratório Nacional de Energia e Geologia, I.P.	Pt	1	1	1	1	1	1	1	1	1	1	1
Bränselaboratoriet Umeä AB	Se	1	1	1	1	1	1	1	1			1
SP	Se	1	1	1	1	1	1	1	1	1	1	1
DBFZ	Ge	1	1	1	1	1	1	1	1	1	1	1
Eurofins Environment Sweden AB	Se	1	1	1	1	1	1	1	1	1	1	1
Belab AB	Se	1	1	1	1	1	1	1	1			1
DOOSAN Babcock	Uk	1		1	1	1	1	1	1	1	1	1
TES	Uk	1	1	1	1	1	1	1	1	1	1	1
TP inspection	USA	1	1	1	1	1	1	1	1			

Thank you for your attention!

This presentation was prepared in close co-operation with:

DBFZ offi

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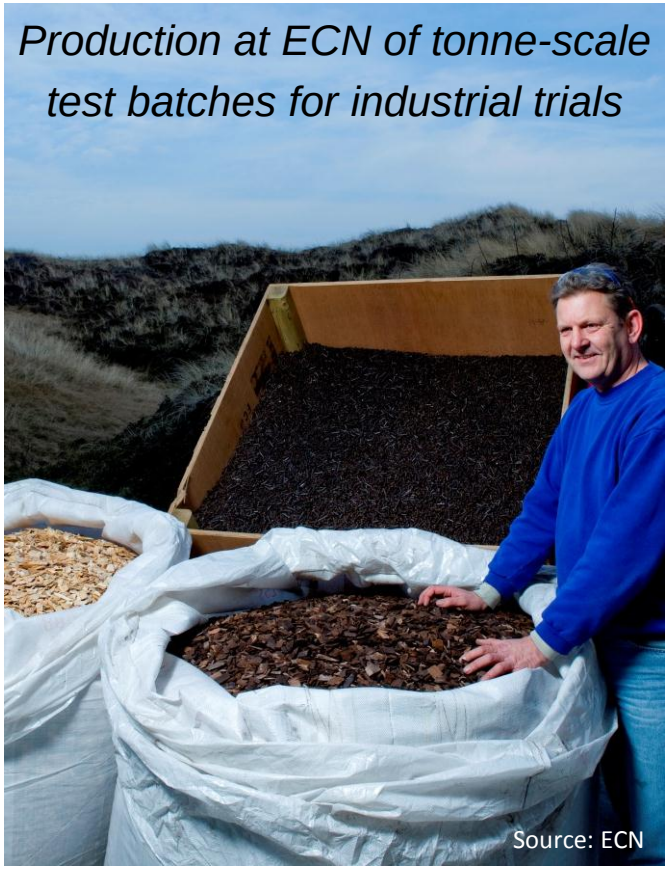

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