BO_2-technology for biomass upgrading into solid fuel - pilot-scale testing and market implementation

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ECN

Energy research Centre of the Netherlands

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BO_2-technology for biomass upgrading into solid fuel - pilot-scale testing and market implementation

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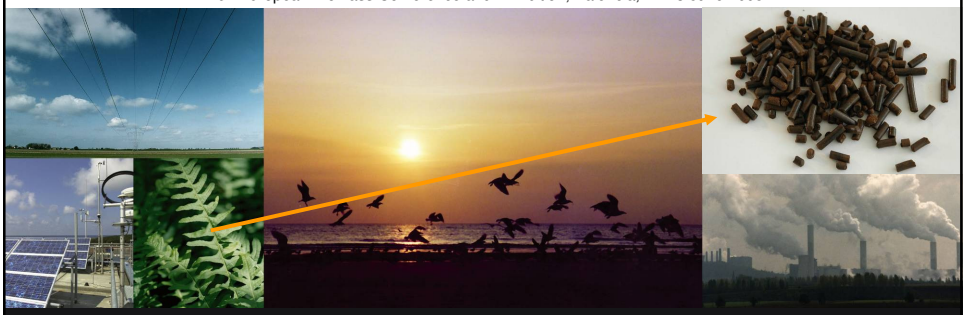


ECN

BO_2

Presentation overview

- Biomass – a difficult energy source
- Torrefaction
- BO_2-technology
- Bench-scale testing
- Pilot-scale testing
- Market introduction
- Conclusions

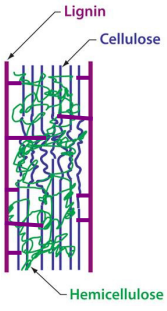
Biomass – a difficult energy source

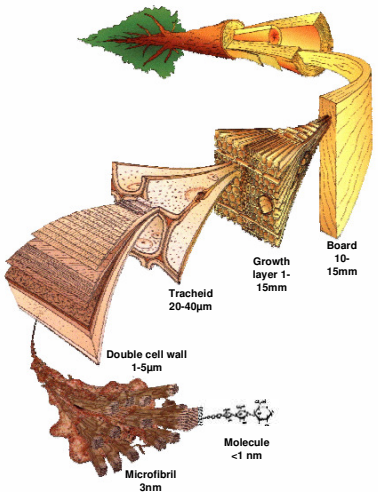
- Production
- Harvesting, collection
- Handling
- Transport
- Storage
- Pre-treatment (e.g., milling)
- Feeding
- Conversion



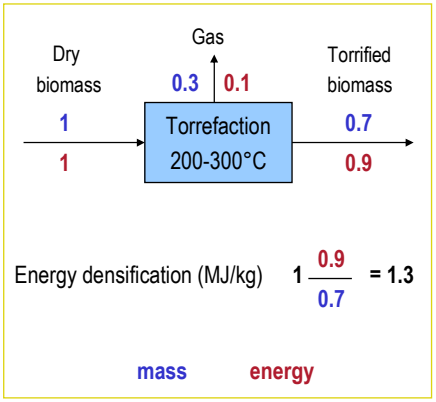

Biomass – a difficult energy source

- Tenacious and fibrous (grinding difficult)
- Low energy density (LHV$_{ar}$ = 10-17 MJ/kg)
- Hydrophilic
- Vulnerable to biodegradation
- Heterogeneous





Torrefaction for upgrading biomass



Process parameters

- Temperature: 200-300°C
- Residence time: 10-30 minutes
- Particle size: < 4 cm
- Absence of oxygen
- Pressure: near atmospheric

Why torrefaction: from biomass/waste to commodity fuel

Woody biomass

Agricultural residues

Friable and less fibrous
19 - 22 MJ/kg (LHV, ar)
Hydrophobic
Preserved
Homogeneous

Superior fuel properties:
- Transport, handling, storage
- Milling, feeding
- Gasification, combustion
- Feedstock range
- Standardisation

Mixed waste

Torrefaction and pulverisation

Fuel powder

Pelletisation

Fuel pellets

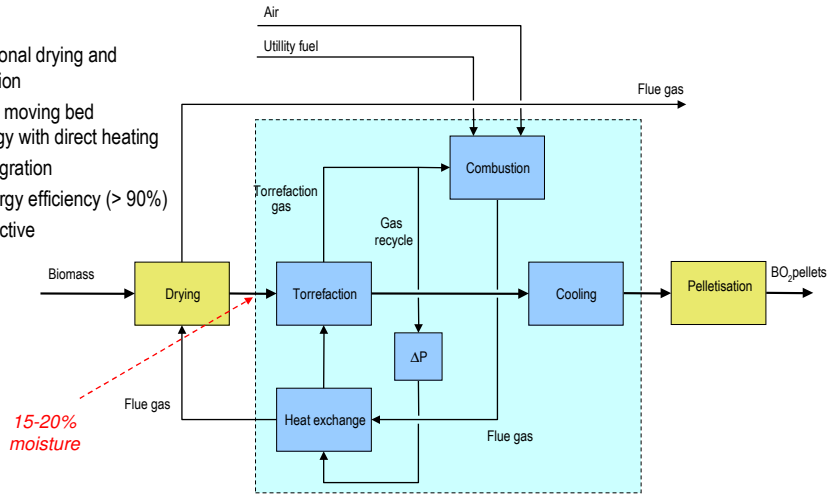
Tenacious and fibrous
10 - 17 MJ/kg (LHV, ar)
Hydrophilic
Vulnerable to biodegradation
Heterogeneous

Bulk density 700-800 kg/m³
Bulk energy density 13-17 GJ/m³

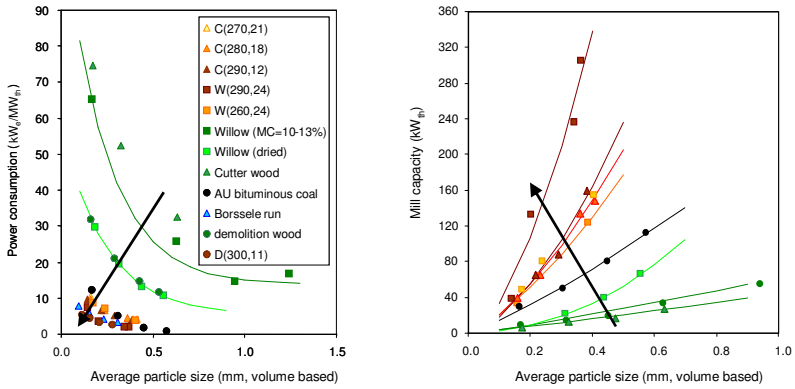
BO_2-technology

Features:

- Conventional drying and pelletisation
- Compact moving bed technology with direct heating
- Heat integration
- High energy efficiency (> 90%)
- Cost effective



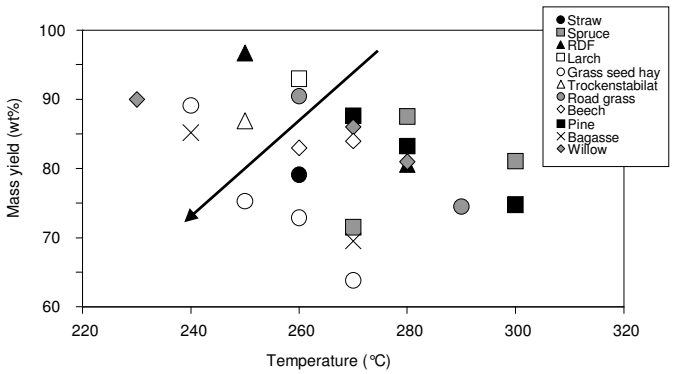
Grindability of (torrefied) woody biomass



Torrefaction leads to a dramatic decrease in required milling power and increase in milling capacity

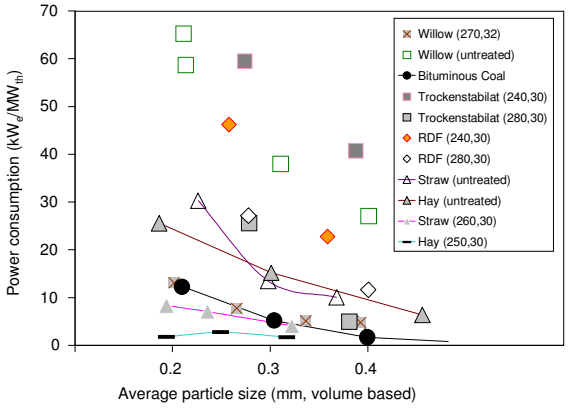
Torrefaction of agro residues and mixed wastes

- Agro residues: torrefaction behaviour comparable to woody biomass, determining factor is hemicellulose content
- Mixed wastes: good prospects, but dependent on composition



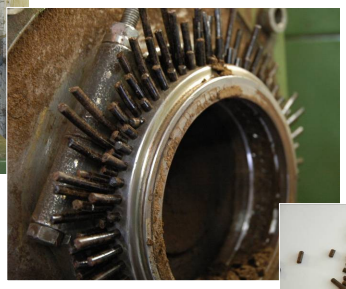
Torrefaction of agro residues and mixed wastes

- Also for these feedstocks large positive effect on grindability



Bench-scale pelletisation tests

Features:
- 10 kg/h
- No automatic moisture supply

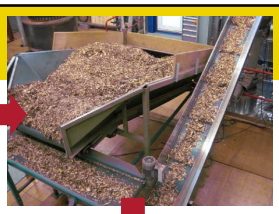


- Preliminary findings:
  - Easy pelletisation
  - Low energy input required
  - Pellet quality strongly dependent on torrefaction and pelletisation conditions

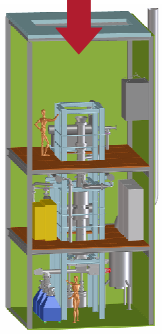
BO_2pellets in perspective

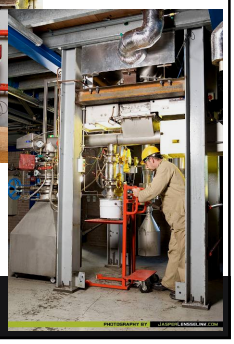
Properties (typical values)	unit	Wood	Torrefied Wood	Wood pellets	BO_2pellets
Moisture content	% wt.	35%	0%	10%	3%
Calorific value (LHV)					
Dry	MJ/kg	17.7	20.4	17.7	20.4
As received	MJ/kg	10.5	20.4	15.6	19.9
Mass density (bulk)	kg/m3	475	230	650	750
Energy density (bulk)	GJ/m3	5.0	4.7	10.1	14.9
Pellet strength				Good	Very good
Hygroscopic nature		Hydrophilic	Hydrophobic	Hydrophilic	Hydrophobic
Biological degradation		Fast	Slow	Fast	Slow
Handling properties		Normal	Normal	Good	Good

Pre-drying



Feeding





Torrefaction pilot-plant testing (50-100 kg/h)

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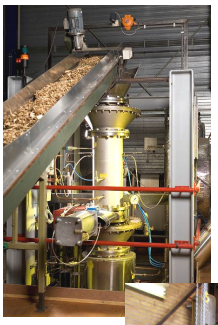
Pilot-scale testing

- Validation of reactor and process concept
- Optimisation of process conditions for a broad feedstock range (woody biomass, agro-residues)
- Semi-industrial pelletisation tests
- Extensive quality evaluation BO$_2$pellets, e.g.
  - strength
  - hygroscopic nature
  - biodegradation
  - milling characteristics
  - combustion / gasification reactivity

Pilot-scale testing – first results

- Over 75 hours of operation with a softwood/ hardwood mixture:
  - Smooth operation
  - Torrefaction conditions: 220-280 °C torgas inlet temp., throughput approx. 60 kg/h (input basis)
  - Torrefaction modestly exothermic, reactor showed good temperature control
- Torrefied material from pilot-plant subjected to initial bench-scale and semi-industrial-scale pelletisation tests at CPM:
  - Good quality pellets can be produced, despite heterogeneous nature of the biomass
  - Strong influence of torrefaction conditions
- Next tests:
  - Optimisation torrefaction + pelletisation for woody fuels
  - Long-duration performance
  - Other feedstocks (agro residues)



BO_2-technology – market potential

..... some figures

- EU-27: coal-fired plants with 10% co-firing requires 70 Mtonne/a dry biomass ≅ 700 BO_2-plants with plant-size 100 ktonne/a.
- EU-27: 10% biofuels in 2010, ≅ 1300 PJ/a, corresponding to approx. 110 Mtonne/a dry biomass (@ 60% conversion efficiency). BO_2-technology is an enabling technology for HT gasification-based BtL.
- EU-15: 43 Mtonne/a dry biomass (agro-residues) available for energy purposes; substantial possible role of BO_2-technology to increase efficiency and reduce cost of overall biomass-to-energy chain.

BO_2-technology – demonstration and market introduction

- Industrial partnership formed with Econcern and Chemfo aimed at technology demonstration and market introduction

ECN	BO_2Rights	IP and R&D services
ECONCERN	BO_2GO	Preparing market introduction of BO_2pellets 1st commercial plant (Delfzijl, the Netherlands, approx. 70 ktonne/a, start-up late 2009)
Chemfo	BO_2Unlimited	Engineering and supply of commercial BO_2-plants

In conclusion

- BO_2-technology allows cost-effective production of 2nd generation biomass pellets from a wide range of biomass/waste feedstock with a high energy efficiency (>90%)
- BO_2pellets show:
  - High energy density
  - Water resistant
  - No/Limited biological degradation and heating
  - Excellent grindability
  - Good combustion and gasification properties
- BO_2-technology is an enabling technology for biomass (co-)firing in entrained-flow gasifiers and gasification-based biofuels production
- Other fields of application:
  - Long distance biomass transport
  - Co-firing in pf boilers
  - Small-scale pellet boilers/stoves

- Pilot-plant testing ongoing, industrial partnership for 1st plant and commercialisation established, strong market pull for BO_2-plants and BO_2pellets

Thank you for your attention……

For more information,
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