TORREFIED BIOMASS

A Foresighting Study into the Business Case for Pellets from Torrefied Biomass as a New Solid Fuel

Paul Mitchell	University of Aberdeen
Jaap Kiel	ECN
Bill Livingston	Doosan Babcock
Georges Dupont-Roc	ITI Energy

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Why the Study?

- Wood pellets are a well established solid fuel for space heating and co-firing with coal
- Global market for wood pellets in 2005 - 7M tonnes/y, equivalent to $1Bn
- The market is limited because:
  - Wood pellets can only be made from saw dust
  - The logistics process of manufacture and distribution is expensive
  - Wood pellets are difficult to store as they re-wet, go mouldy and lose dry matter
  - There are technical restrictions on the % of wood pellets that can be co-milled due to their high fibre content
- The ready availability of wood in Scotland makes the torrefaction of biomass an area worth exploring further

Wood Fuels – Chips to Pellets

Market Drivers

- There is a clear market need for new forms of sustainable, clean solid fuels with high energy density.
- The global market opportunity is estimated to be many 10's millions of tonnes/y
- The market applications include:
  - Space heating – commercial and domestic
  - Power generation via co-firing
- Fuels that complement existing infrastructure e.g. boilers, will be adopted more quickly
- Wood pellets are competitive with heating oil at current oil prices ($60/barrel)

What is it?

- Biomass that has been thermally pre-treated.
  - Involves heating biomass to 250 – 300^{o}C for ~ 60 minutes
  - Biomass is partially decomposed
  - Solid product has very different properties compared with the parent material
  - Has a higher energy density fuel than wood pellets
- Biomass for torrefaction should be a lignocellulosic material such as:

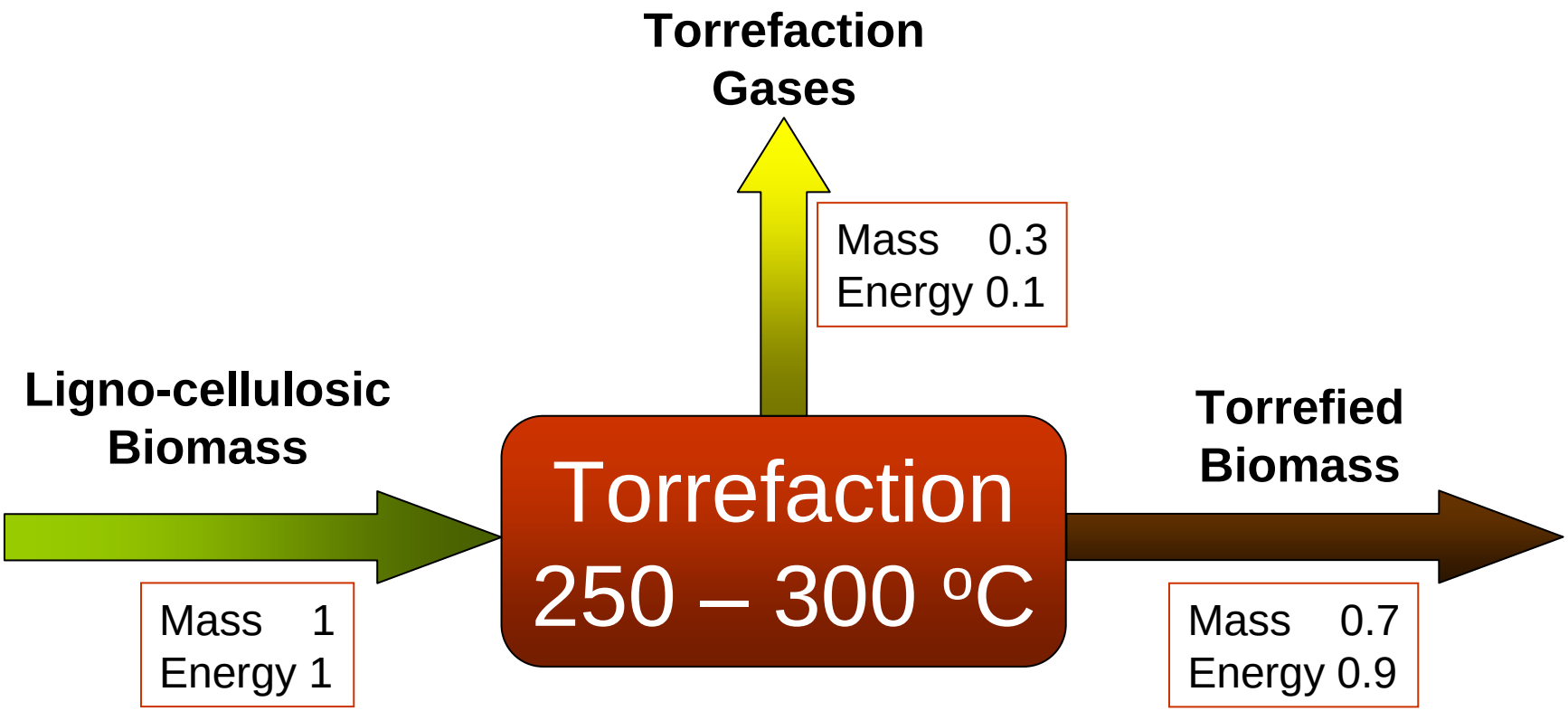
Wood Straw Energy Crops

Torrefied Biomass

Properties

	Wood Chips	Wood Pellets	TOP Pellets
Moisture Content (%)	35	10	3
Calorific Value (MJ/kg)	10.5	16	21
Bulk Density (kg/m^3)	550	600	800
Energy Bulk Density (GJ/m^3)	5.8	9	16.7
Hygroscopic Nature	Wets	Wets	Hydrophobic
Behaviour in Storage	Gets mouldy Dry matter loss	Deteriorates Gets mouldy	Stable

Mass & Energy Balance



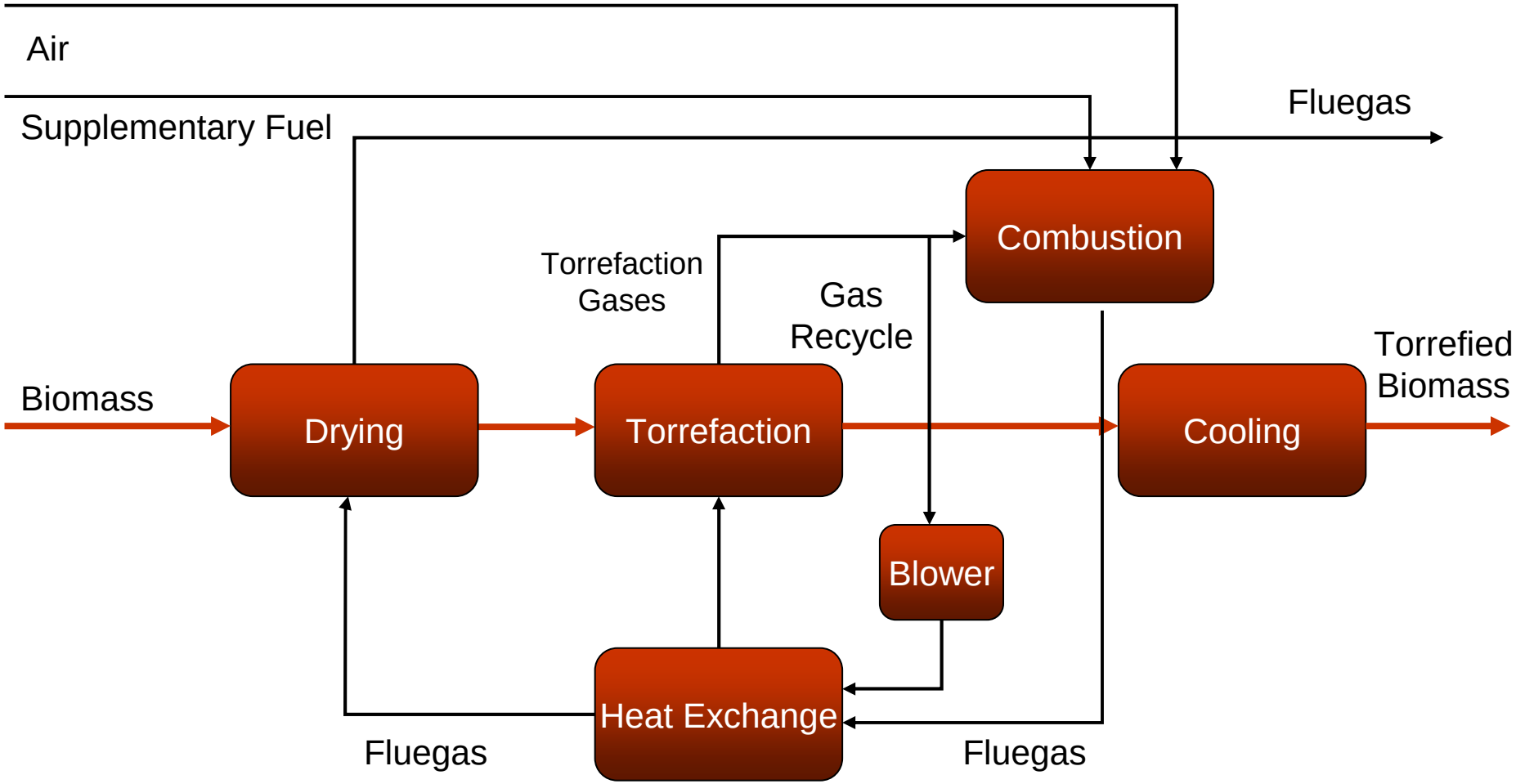
Thermal Decomposition Regimes

- Woody biomass is composed of:
  - Hemicellulose
  - Cellulose
  - Lignin
- Below 250^{o}C
  - Biomass dried
  - Softens lignin
  - Devolatilisation & carbonisation of hemicellulose
- Above 250^{o}C
  - Hemicellulose decomposes into volatiles and char
  - Limited devolatilisation & carbonisation of lignin & cellulose

ECN Torrefaction Technology

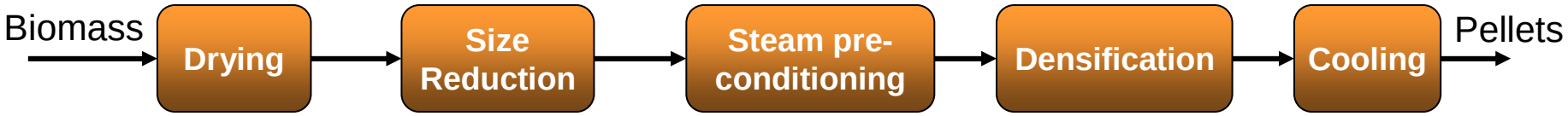
- Optimisation of process design to reduce production costs:
  - Compact reactor with high heat transfer rate and temperature control
  - High Energy Efficiency
  - Minimise reactor residence time
  - Optimise grindability of product
  - Energy Densification via pelletisation

ECN Torrefaction Technology



The TOP Process

Pelletisation



Torrefaction

Torrefaction & Pelletisation (TOP Process)

Sources of Biomass

- Any ligno-cellulosic biomass:
  - Forest Residues
  - Co-products from sawmilling industry
  - Co-products for wood processing industry
  - Short rotation coppice plantations

Process Simulation & Costs

- Output of plant 47MWth = 80,000 t/y TOP pellets
- Feedstock prices
  - Current market prices
- Process costs estimated on basis of:
  - Mass & Energy balance
  - Equipment design
- Three Cases:
  - 1 – Sawmill co-products (50% MC)
  - 2 – Forest residues (35% MC)
  - 3 – Wood industry co-products (25% MC)

Costs of Producing TOP Pellets

Feedstock Supply & Production Costs for 80,000 t/y TOP pellets (€/t)

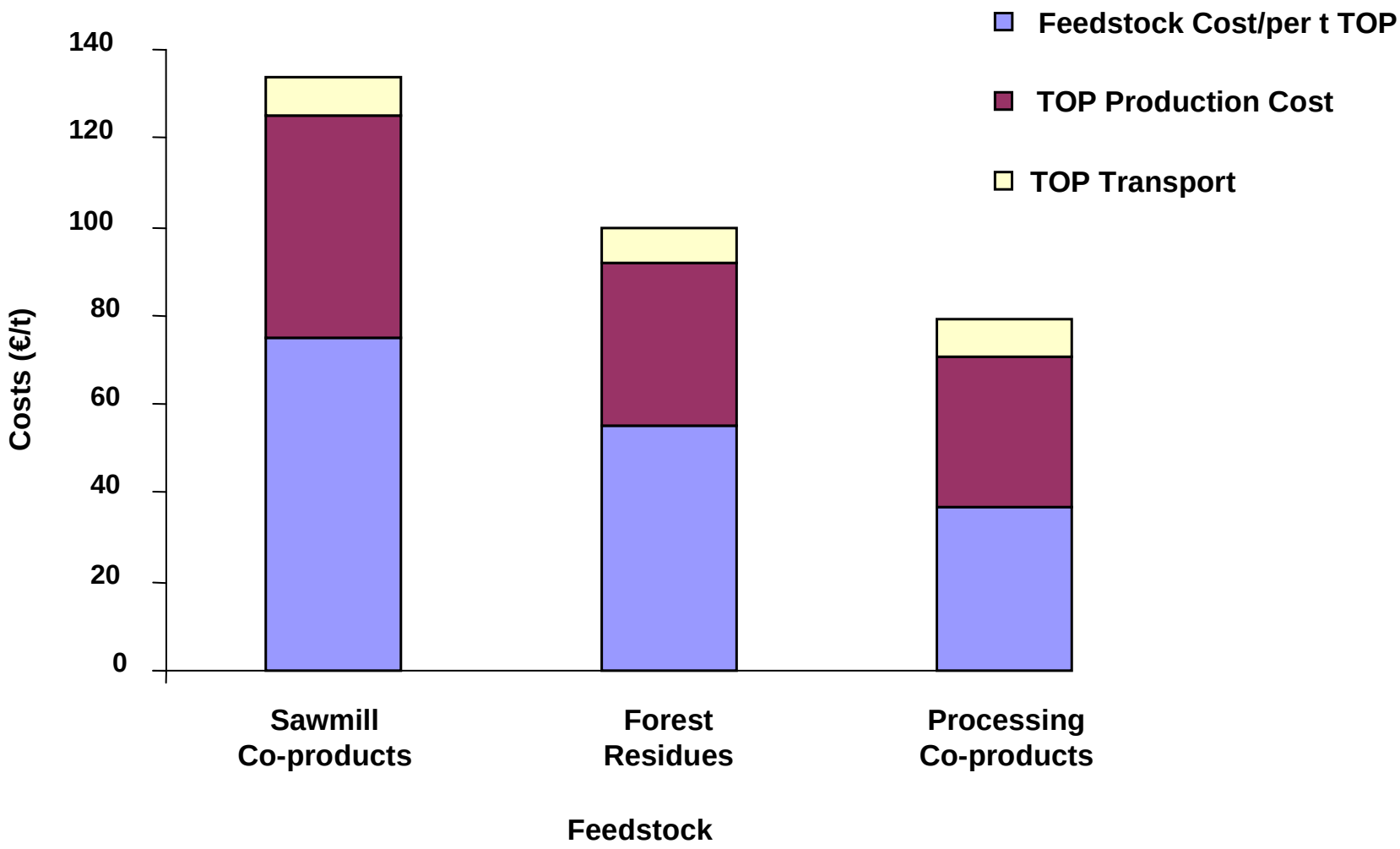
	Sawmill Co-Products	Forest Residues	Wood Processing Co-products
Moisture Content (%)	50	35	25
Feedstock Required (kt/y)	200	146	118
Total Capital Investment (M€)	7.2	6.5	6.1
Feedstock Cost / 1 t TOP	75	55	37
TOP Production Cost	50	37	34
Delivered Cost of TOP	133	100	80

Costs of Producing TOP Pellets

Feedstock Supply & Production Costs for 80,000 t/y TOP pellets (€/GJ)

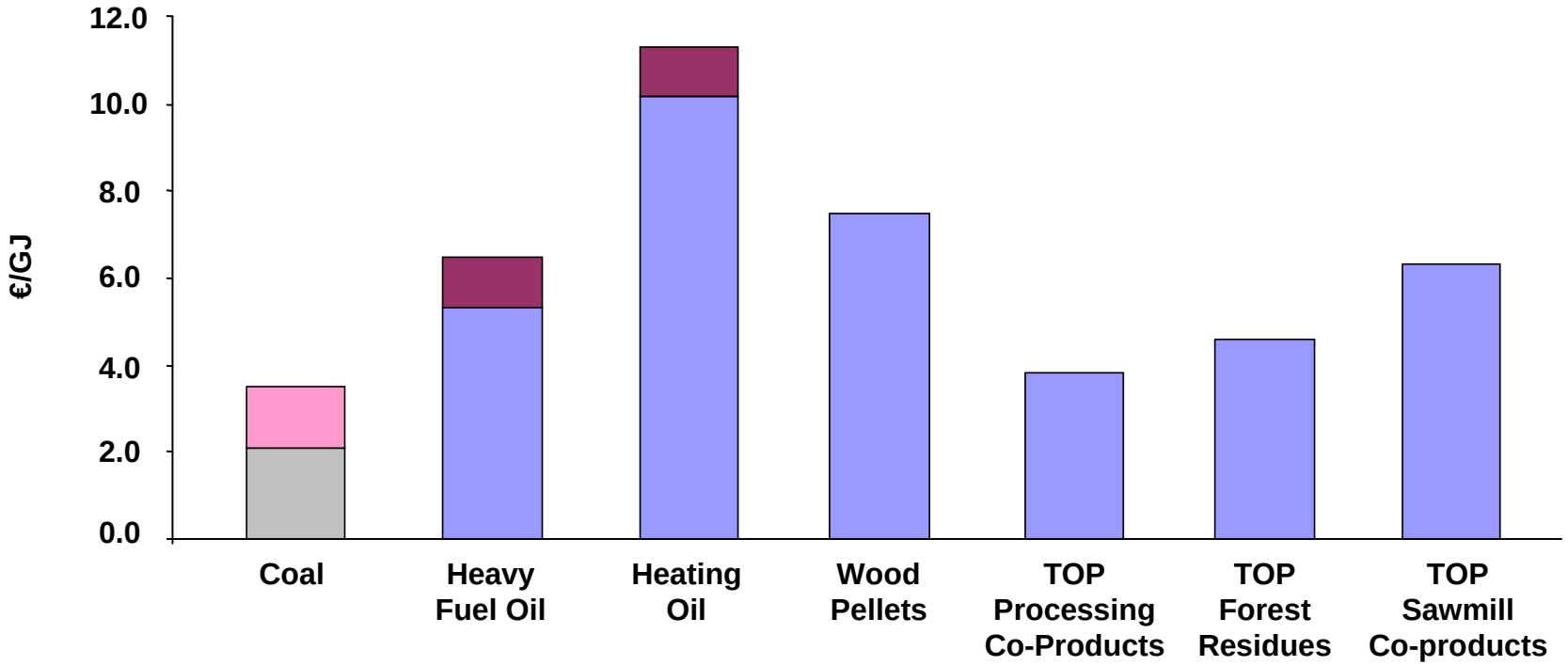
	Sawmill Co-Products	Forest Residues	Wood Processing Co-products
Moisture Content (%)	50	35	25
Feedstock Required (kt/y)	200	146	118
Total Capital Investment (M€)	7.2	6.5	6.1
Feedstock Cost / 1 t TOP	3.6	2.6	1.8
TOP Production Cost	2.4	1.8	1.6
Delivered Cost of TOP	6.4	4.8	3.8

Costs of Producing TOP Pellets



Energy Cost

Energy Cost of Coal, Oil, Wood Pellets & Torrefied Pellets, inclusive of Carbon Emission Price (€15/tCO$_2$)



Conclusions

- Lower moisture content than wood pellets
- Significantly higher calorific value than wood pellets
- High bulk density giving transport advantages
- Energy bulk density nearly twice that of wood pellets
- Torrefied pellets are hydrophobic and more stable in storage

Conclusions

- Torrefied biomass is brittle and has higher grindability than fibrous wood
- Production and delivery costs significantly lower than wood pellets
- Highly competitive with heavy fuel oil and heating oil
- Highly competitive when co-firing with coal
- Premium feedstock for gasification and Biomass to Liquid (BTL) technologies


Espresso Lover