



Overview of international developments in torrefaction

Central European Biomass Conference 2011

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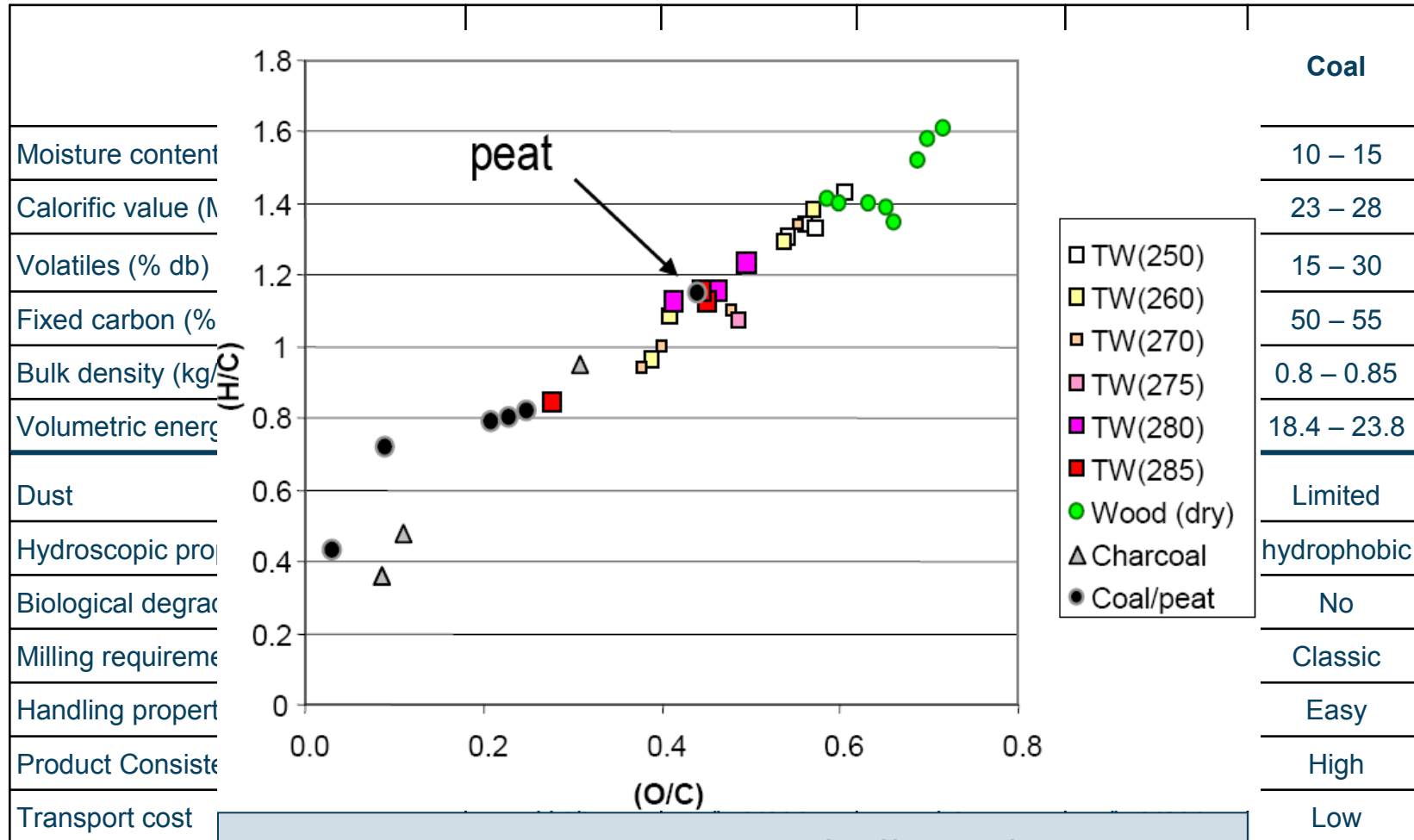
KEMA Nederland B.V.

28 January, 2011

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Indicative fuel properties



Van Krevelen diagram of different fuels

The added value of torrefaction

Higher co-firing percentages

Torrefied product can be directly milled and co-fired with the coals. Product is dry ($< 5\%$) and has a calorific value of 20 – 22 MJ/kg. The product is brittle and easily breaks down in small particles

Torrefaction alone will NOT:

- Significantly reduce sulfur, chlorine and alkali concentrations of the biomass
- As a result, co-firing percentages are still limited by the impact on boiler integrity (corrosion, slagging and fouling)

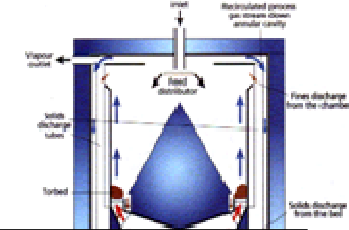
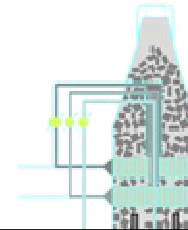
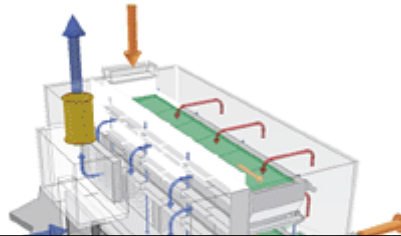
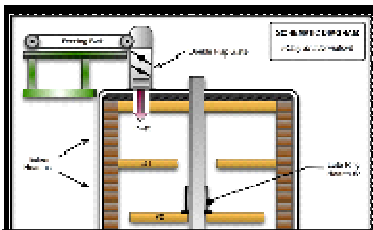
Cost savings long distance transport

The volumetric energy density of torrefaction pellets is 16 GJ/m³ compared to 10 GJ/m³ for wood pellets. This implies significant cost savings

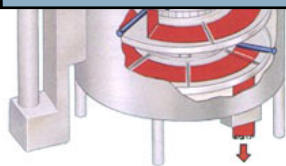
Market potential of torrefied biomass

Market segment	Conversion process	Conversion technology	State-of-the-art biofuel	Pre-treatment requirements	Advantages of torrefaction	Market potential
	Co-firing	Coal-fired	Wood pellets	High	Process with the	Large
• Market of torrefaction is driven by renewable energy targets and cost savings • Torrefied product can be applied in different market segments • The co-firing market is very attractive (volume, prices, subsidies) • The demand in Europe alone, will be millions of tonnes • Industrial and residential heating markets have a large potential						
Residential/ District heating	Combustion	Stoves	Wood pellets	High, decentralized	Transport savings	Large

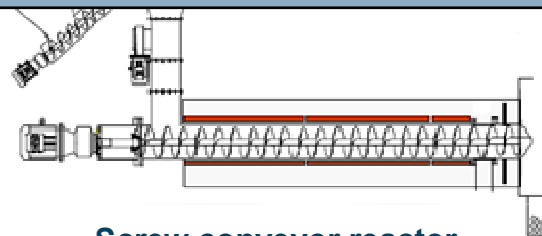
Torrefaction technologies



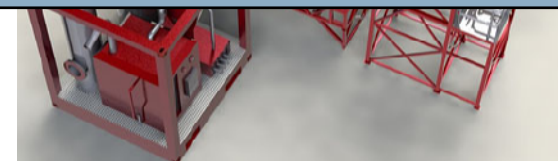
- Most reactor technologies applied for torrefaction are proven in other applications (combustion, drying, gasification ect.)
- Every reactor technology has specific advantages and disadvantages (KEMA Torrefaction Benchmark)
- Overall efficiency also depends on heat integration design, in which different options are possible (direct or indirectly heated)
- Process control (residence time, temperature, particle size feed, mixing) is the key for good performance



TurboDryer

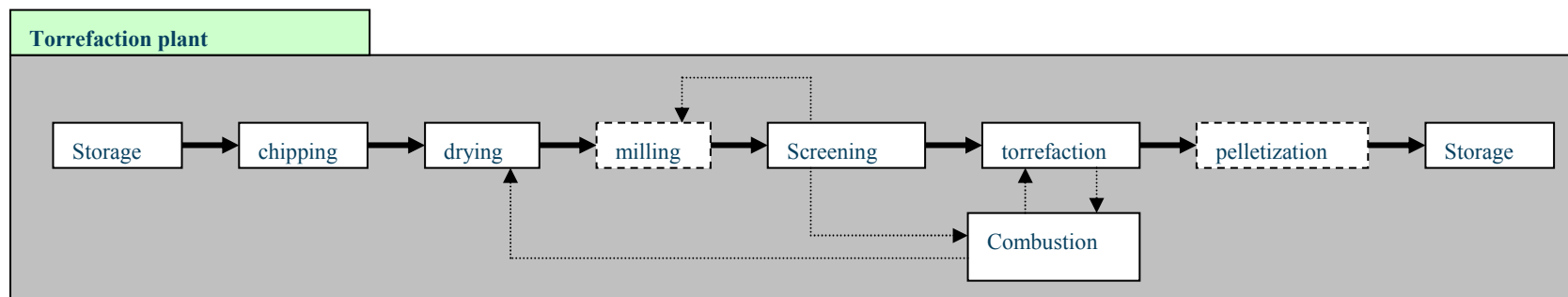
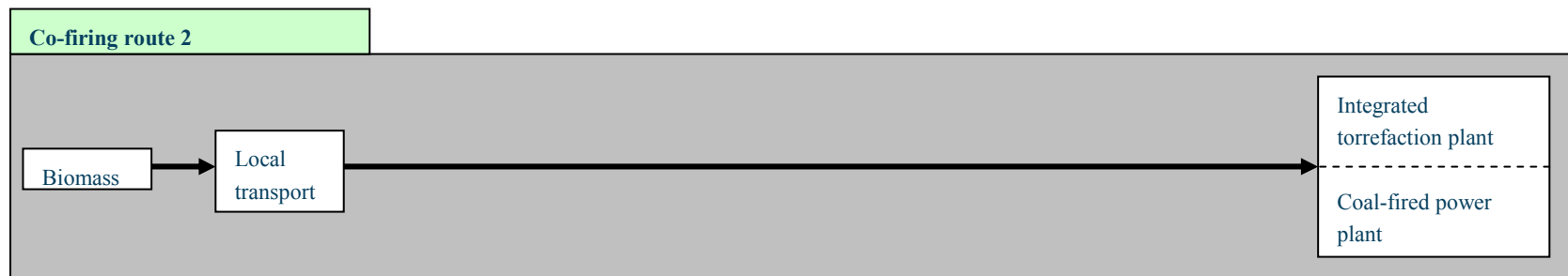
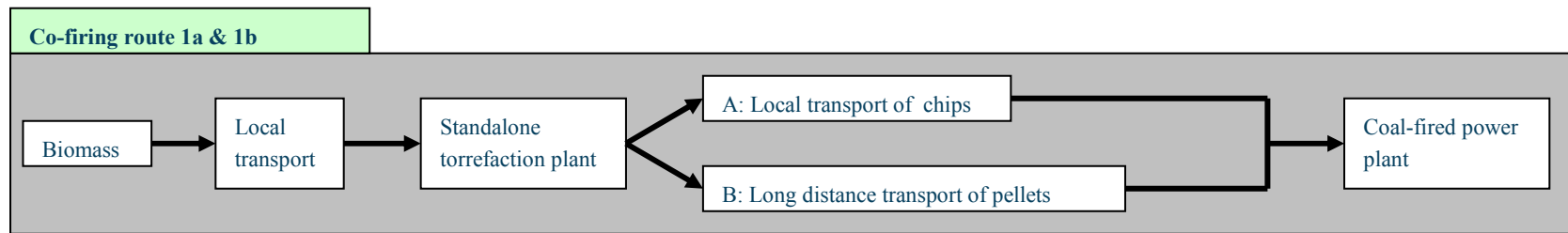


Screw conveyor reactor



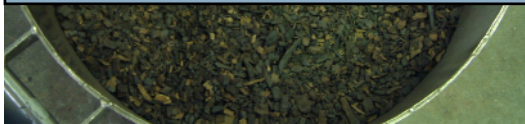
Mirco wave reactor

at the biomass source or at the power plant?



Product samples of torrefaction

- Most experience built up with (clean) wood torrefaction
- Large differences observed in product properties and quality
- Uncertainties about large scale processing of product (handling, storage, milling, explosion risk, dust and odor emissions, combustion properties)
- Pelletization possible, but in most cases additives are needed (dependent on torrefaction temperature)
- Milled product is highly reactive and should be kept inert



Wood chips



Torrefied wood pellets



Milled torrefied wood

First batch of CoolCoal (Stramproy Green Energy)



Amer power plant of Essent, 29 July, 2010

European torrefaction initiatives

Developer	Technology	T. Supplier	Location(s)	Production capacity (t/a)	Starting operation
Topell Energy B.V. (NL)	Torbed	Torftech Inc (UK)	Duiven (NL)	60,000	Q4 2010
Stramproy Green	Oscillating belt				
• Three commercial demonstration plants starting up in Q4 2010 / Q1 2011 (35,000 – 60,000 kton/year) • Topell Energy has built the largest plant • Stramproy Green Investments has integrated the torrefaction plant with a bio-CHP plant and was the first to deliver product • Torr-Coal has developed a process in which also waste streams like SRF can be processed					
BioEndev (SE) / ETPC (SE)	Rotary drum	Unknown	Ö-vik (SE)	25,000 – 30,000	2011/ 2012
EBES AG (AT)	Rotary drum	Andritz (AT)	Frohnleiten (Austria)	10,000	2011
Atmosclear SA (CH)	Rotary drum	Airless Systems (UK)	Rezekne (Latvia), New Zealand, US	50,000	Q4 2010



* This is not the full list and figures are based on statements of developers

Construction of Topell's 60 kton/year torrefaction plant



**Duiven, The
Netherlands**

Summer 2010

North American torrefaction initiatives

Developer	Technology	Supplier	Location(s)	Production capacity (t/a)	Starting operation
• Torrefaction development is driven by utilities which have to deal with renewable obligation schemes in Canada and in specific states of the US, but also the wood pellets industry is interested in torrefaction • Most of these initiatives are in a less developed stage (pilot plant) compared to the European competitors and the first commercial demonstration plant still has to be built • However, torrefaction development is driven by public and private funding of R&D programs (e.g. DOE, EPRI, Xcel Energy, CEATI, WPAC), in which universities play a important role					
Rotawave, Ltd. (UK)	Mircowave	Group's Vikoma (UK)	Terrace, British Columbia (CA)	110,000	Q4 2011

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The major technical challenges of torrefaction

Feedstock flexibility

Currently torrefaction technologies are mainly processing wood chips for a narrow bandwidth of particle size. Agricultural residues are still a challenge, because it ignites easily, has a low bulk density and has long fibers

Process validation

Although some experience has been gained with pilot plant testing, real operational data will reveal the performance of the torrefaction process. Important is the trade-off between energy yield, product quality and production cost.

Product validation

Although the pilot plant test results were promising, the product needs to be validated by large co-firing trials. Are torrefaction suppliers able to commercially provide a product which meets the specifications of an utility? And is the product really sustainable?

The major business challenges of torrefaction

Financing

Most torrefaction developers are small companies with a limited financial base. Convincing investors to finance the necessary R&D and up-scaling efforts is a real challenge

Market maturity

A dominant torrefaction concept will emerge out of a large variety of technologies and initiatives. But have torrefaction suppliers enough development power to optimize and scale-up their torrefaction concept? A product standardization is needed to make the market more transparent and reliable

Availability of product

The urgency and quantity of demand is significantly higher than the supply. Torrefaction suppliers are facing the challenge to scale-up their first commercial demonstration plants in a rapid pace

KEMA as partner in torrefaction business



Thanks for your attention



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