


LIBRA: Lignin BioRefinery Approach

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LIBRA: LIgNin BioRefinery Approach

Paul de Wild



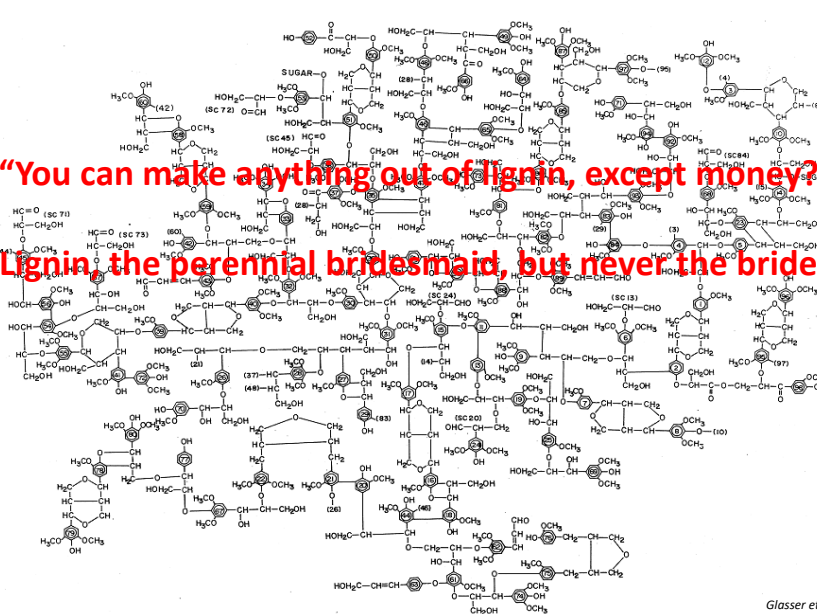
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Idealised molecular structure of a hardwood lignin

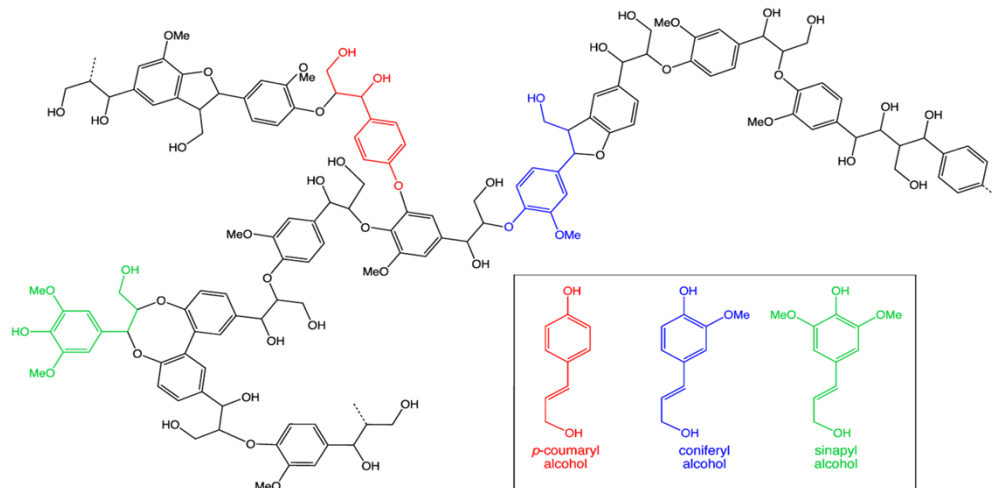



“You can make anything out of lignin, except money?”

“Lignin, the perennial bridesmaid, but never the bride?”

Glasser et al., 1980's



Lignin basic structure and building blocks









Contents

- Introduction lignin and valorisation via LIBRA
- Competitive overview
- Project plan

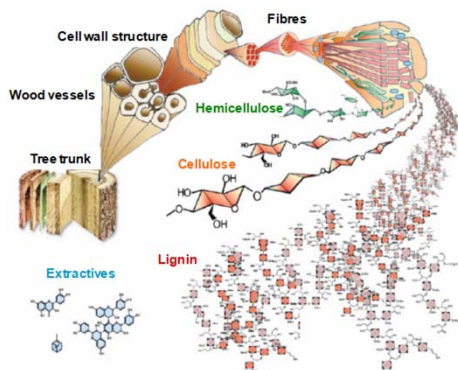





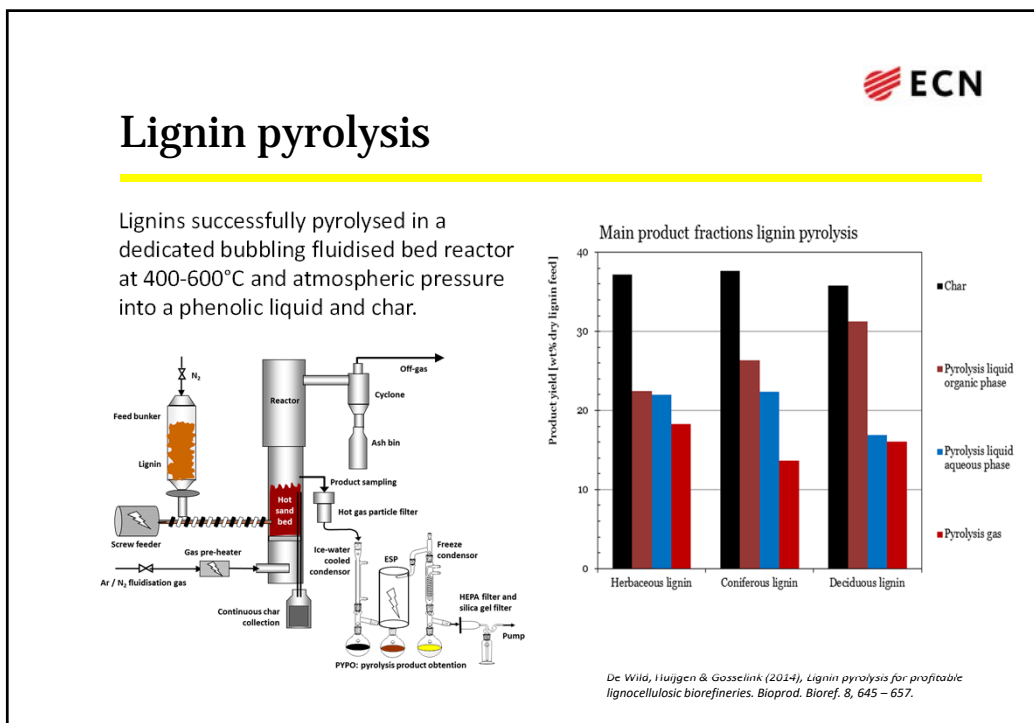
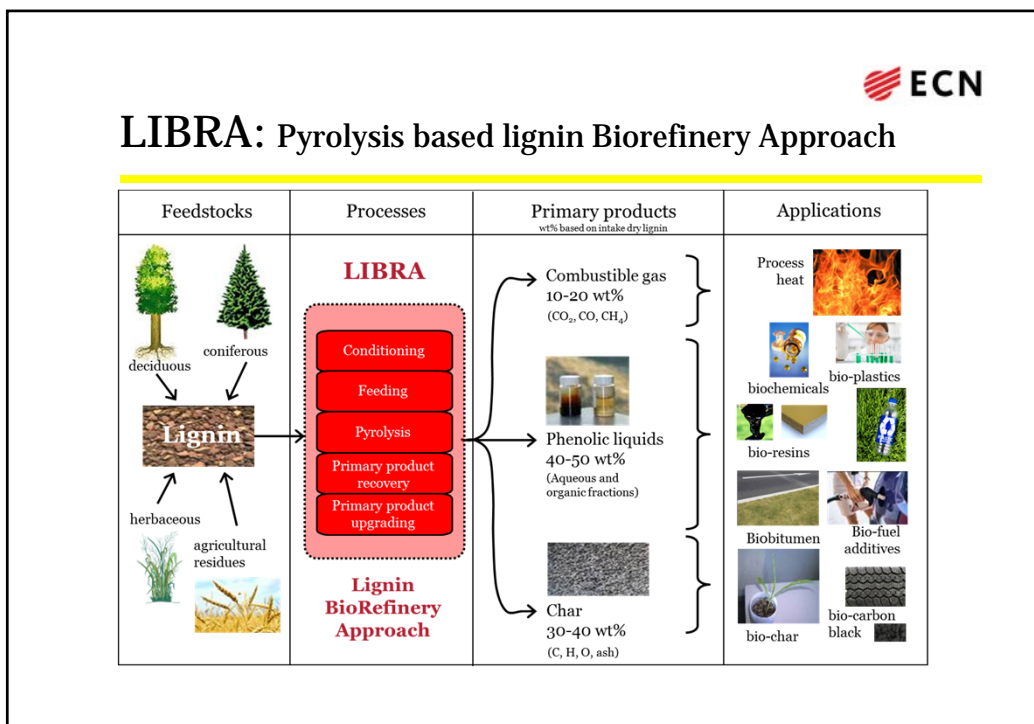


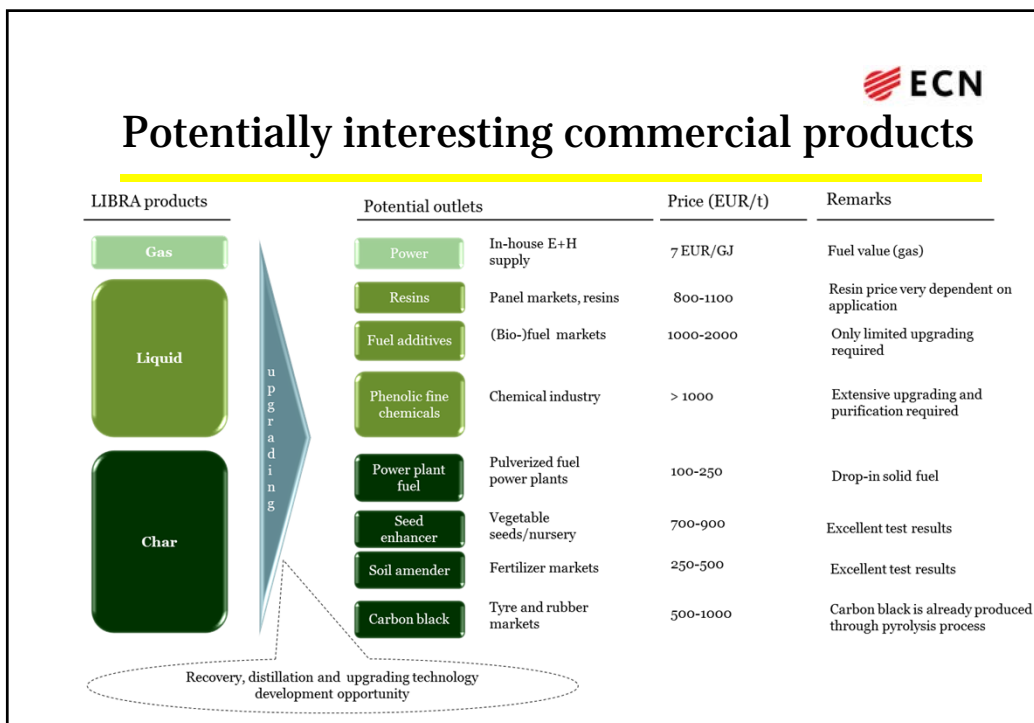
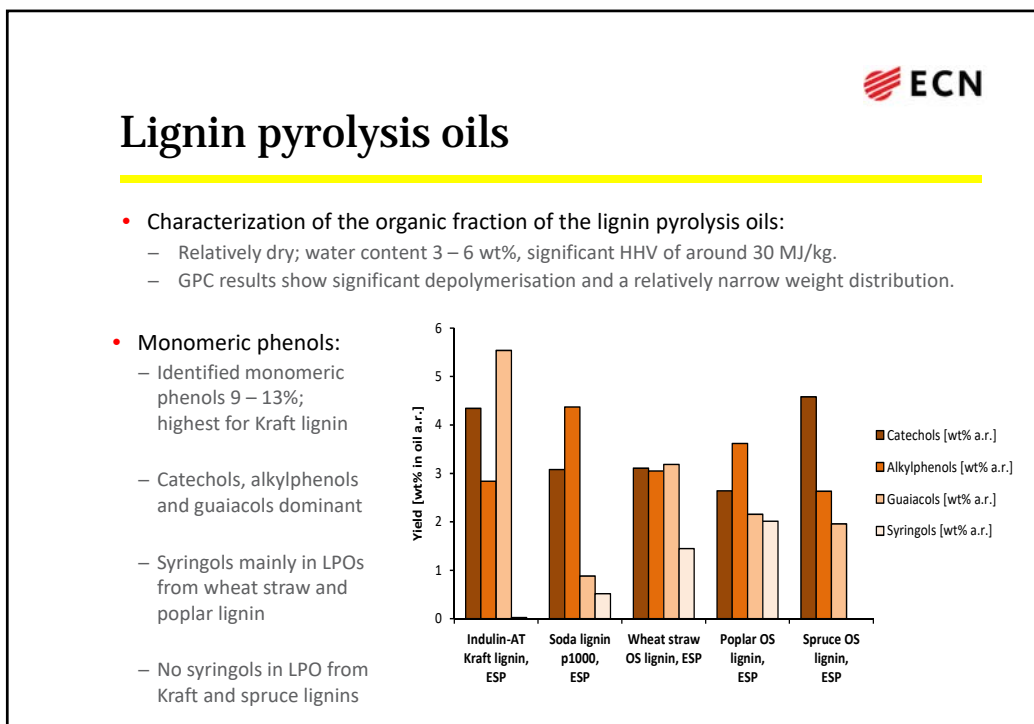
Introduction lignin: Structure, function and valorization beyond fuel value

- Lignin provides structural rigidity, flexibility and microbial protection in plants and woods
 - Lignin is a highly crosslinked network of different phenolics and therefore complex, recalcitrant and very heterogeneous.
- Lignin is abundant side stream from the pulp & paper industry and biorefineries but to date, lignin is mostly burned in industrial processes
 - There is a strong need for a cost-effective conversion into valuable products.
- Lignin can become a major renewable source for aromatics via our Lignin BioRefinery Approach (LIBRA)
 - ECN is developing LIBRA, a pyrolysis-based technology for conversion of lignin into more homogeneous products that can be used for value-added applications such as polymers, resins, aromatic chemicals, biochar, etc.

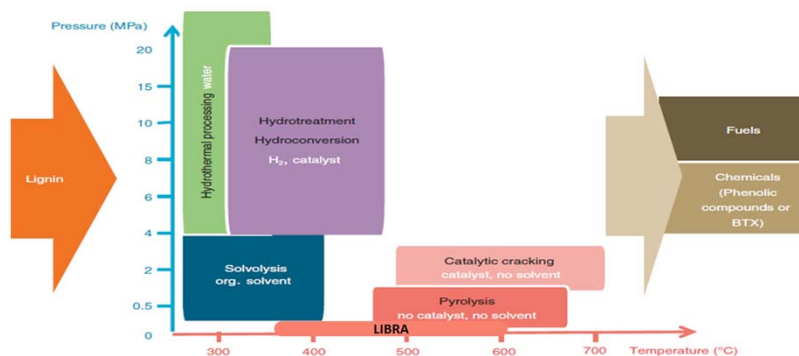


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Competing technologies lack most of LIBRA's strong points



Adapted from Joffres et al., 2013

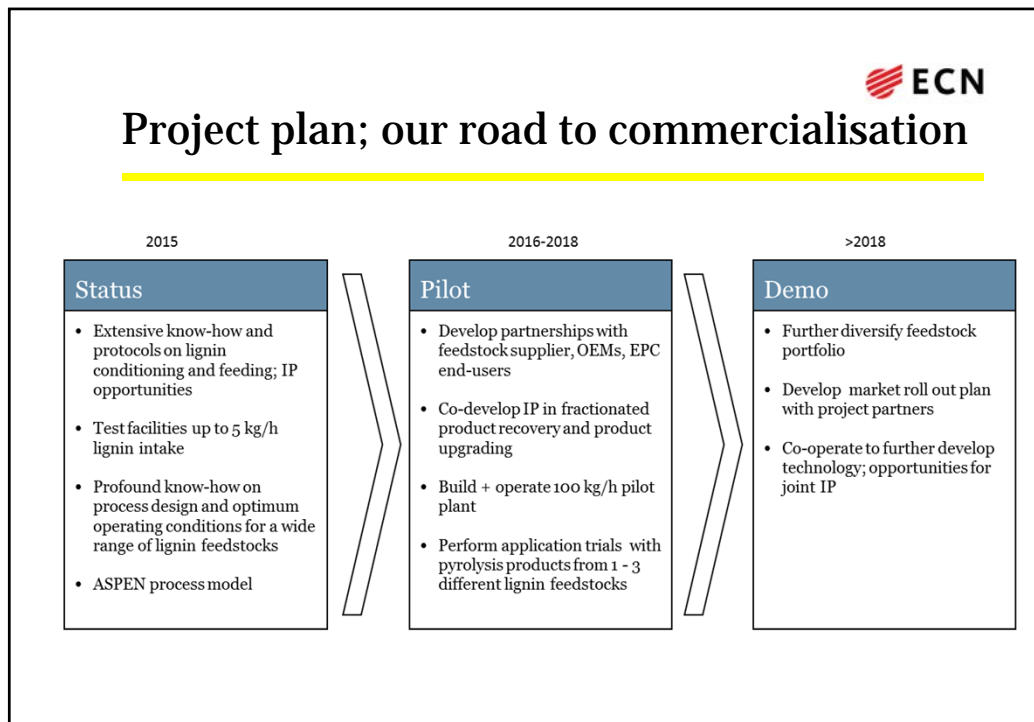
- USPs of the ECN LIBRA process:
 - LIBRA process is pyrolysis-based and suitable for various lignins
 - Milder and flexible operating conditions (atmospheric pressure, moderate temperatures, no catalysts, ease of operation,...) --> lower CAPEX and OPEX, and higher energy efficiency
 - Cost competitive at relatively modest scale (15 kt/a)

LIBRA: competitive overview

INDICATIVE!

Lignin valorization		Technology robustness		
		Strong	Average	Weak
Technology complexity	High			Solvolysis
	Medium		Hydro thermal	
	Low	LIBRA	Cracking	

Process technology	Competitive edge of ECN
Catalytic hydrothermal treatment; small-scale (mg-g) activities in batch mode, severe reaction conditions	Continuous process, no catalyst required, feasible at larger scale Low CAPEX/OPEX, much larger scale of operation (kg)
Catalytic solvolysis (organic solvents); small-scale (mg-g) activities in batch mode, severe reaction conditions	Continuous process, no catalyst required, feasible at larger scale Low CAPEX/OPEX, much larger scale of operation (kg)
(Catalytic) cracking (sporadically reported on small (g) batch lab-scale)	No catalysts required, low CAPEX/OPEX, feedstock tolerance, feedstock flexibility



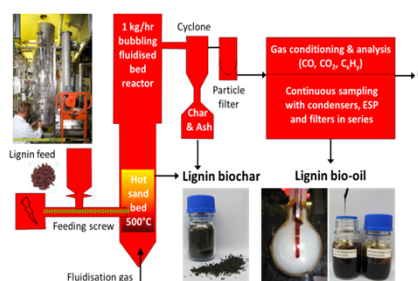
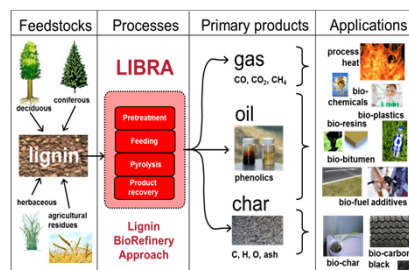
Lignin BioRefinery Approach for chemicals, materials and fuels

ECN can offer:

- Fractionation and purification technology on kg-scale to isolate pure lignin from biorefinery recalcitrant wastes e.g. via organosolv, aquathermolysis and membrane separations.
- Full chemical and biochemical characterisation of lignin.
- Dedicated pyrolysis technology on kg-scale to thermochemically depolymerise lignin into a phenolic bio-oil, biochar and combustible gas.
- Down stream processing technology to recover lignin pyrolysis oil fractions, e.g. by staged condensation.
- Limited application trials of lignin and fractions thereof.

ECN is looking for:

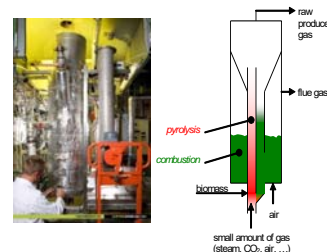
- Scale-up of pyrolysis and DSP technologies.
- Industrial partners for application trials with lignin and its fractions both for established uses and to identify new applications.



Pyrolysis facilities at ECN



- **Bubbling fluidised bed (BFB) “WOB”**
 - Multifunctional unit for intermediate and fast pyrolysis, gasification and combustion, automated continuous operation,
 - 1 kg/hr, atmospheric pressure, T up to 1100° C,
 - DSP options (thermal (catalytic) cracking, product recovery, etc.),
 - Feedstocks: biomass, lignin, plastic containing wastes.
- **Entrained flow (EF) – BFB (CFB) “PYRENA”**
 - Multifunctional unit for fast pyrolysis, gasification and combustion, automated continuous operation,
 - 5 kg/hr, atmospheric pressure, T up to 900° C,
 - DSP of product gases,
 - Feedstocks: biomass, plastic containing wastes,..., lignin?
- **Auger moving bed (Pyromaat)**
 - Unit for slow / intermediate continuous pyrolysis, fully automated,
 - 3 kg/hr, atmospheric pressure, T up to 600° C,
 - DSP of product gases (thermal cracking),
 - Feedstocks: several plastic and metal containing wastes (e.g. electronic scrap residu), coal, biomass
- **Analytical pyrolysis - GCMS**
 - High throughput screening, 350 – 1000° C, mg scale, batch operation, several feedstocks



Thank you for your attention!
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