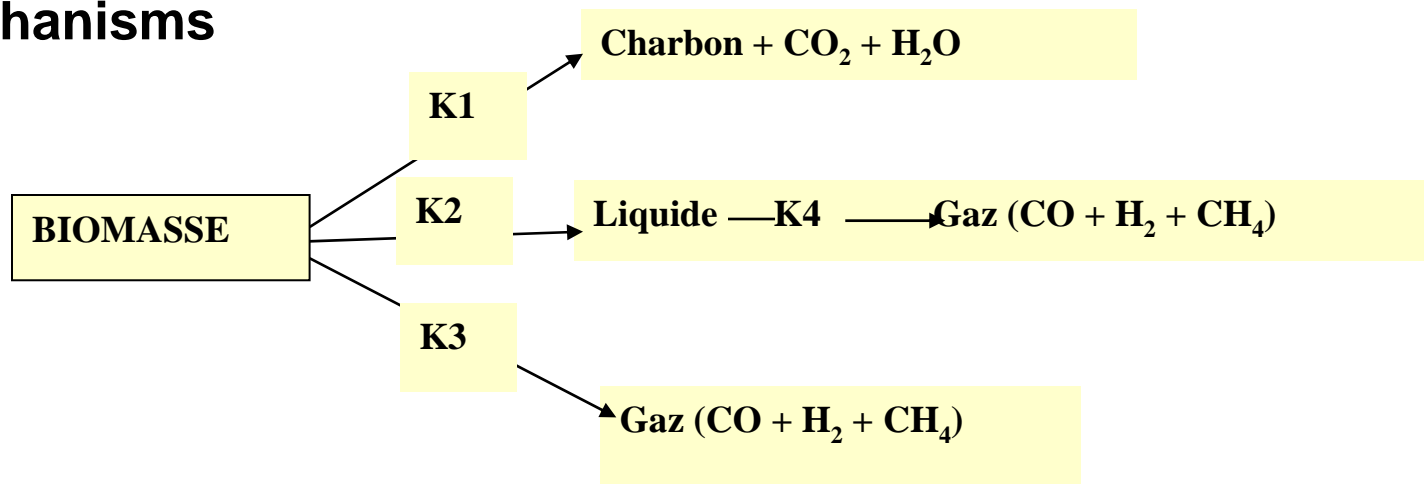


ADVANCED TECHNICAL ISSUES IN CHARCOAL PRODUCTION

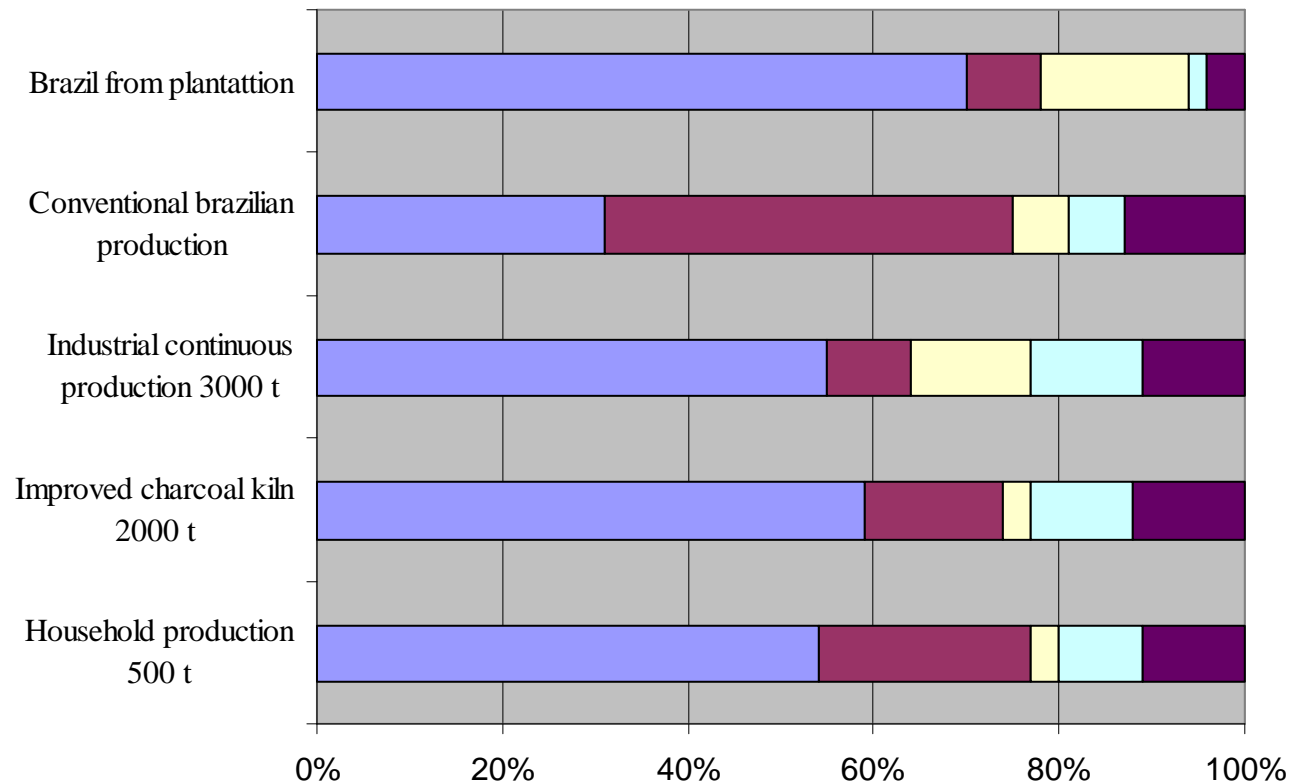
**P. GIRARD, Head of biomass energy
research unit Cirad-Forêt**

PRINCIPLE

- Heating of biomass in absence of oxygen in the range of 500°C
- Depending on operating conditions :
 - solid (long residence time, pressure)
 - liquid (short residence time for vapour, high heating rate)
 - gas (high temperature, high heating rate)
- Mechanisms



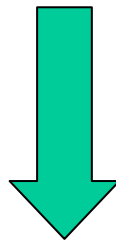
CHARCOAL PRODUCTION COST BREAKDOWN



Raw matériel Manpower other runing cost depreciation Financial charges

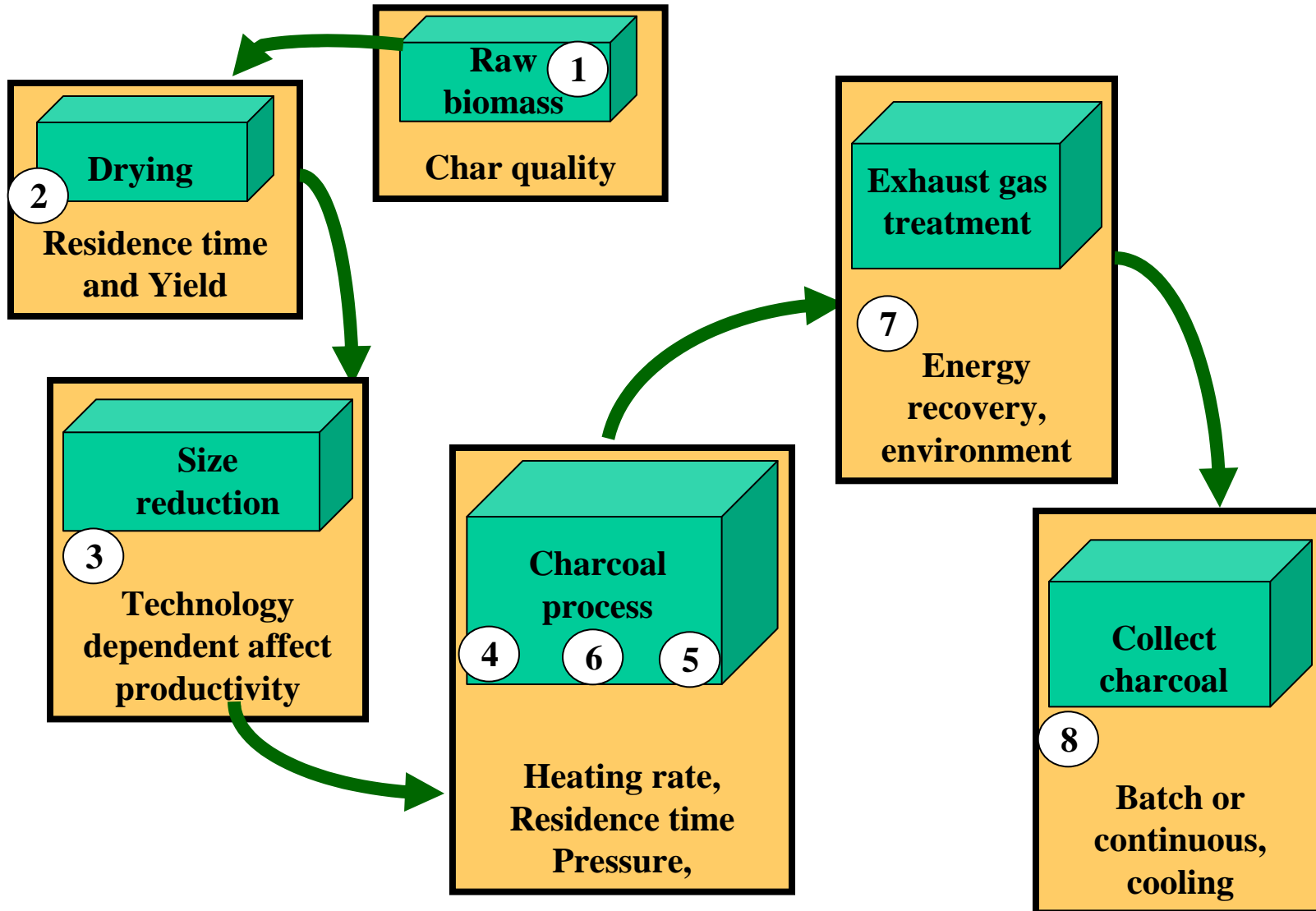
CHARCOAL PRODUCTION COST BREAKDOWN

Feedstock and man power represent the main costs (almost 80%) and not the capital cost



Offers large opportunity for technology improvements

CHARCOAL PRODUCTION PROCESS



CHARCOAL PRODUCTION IMPROVEMENT

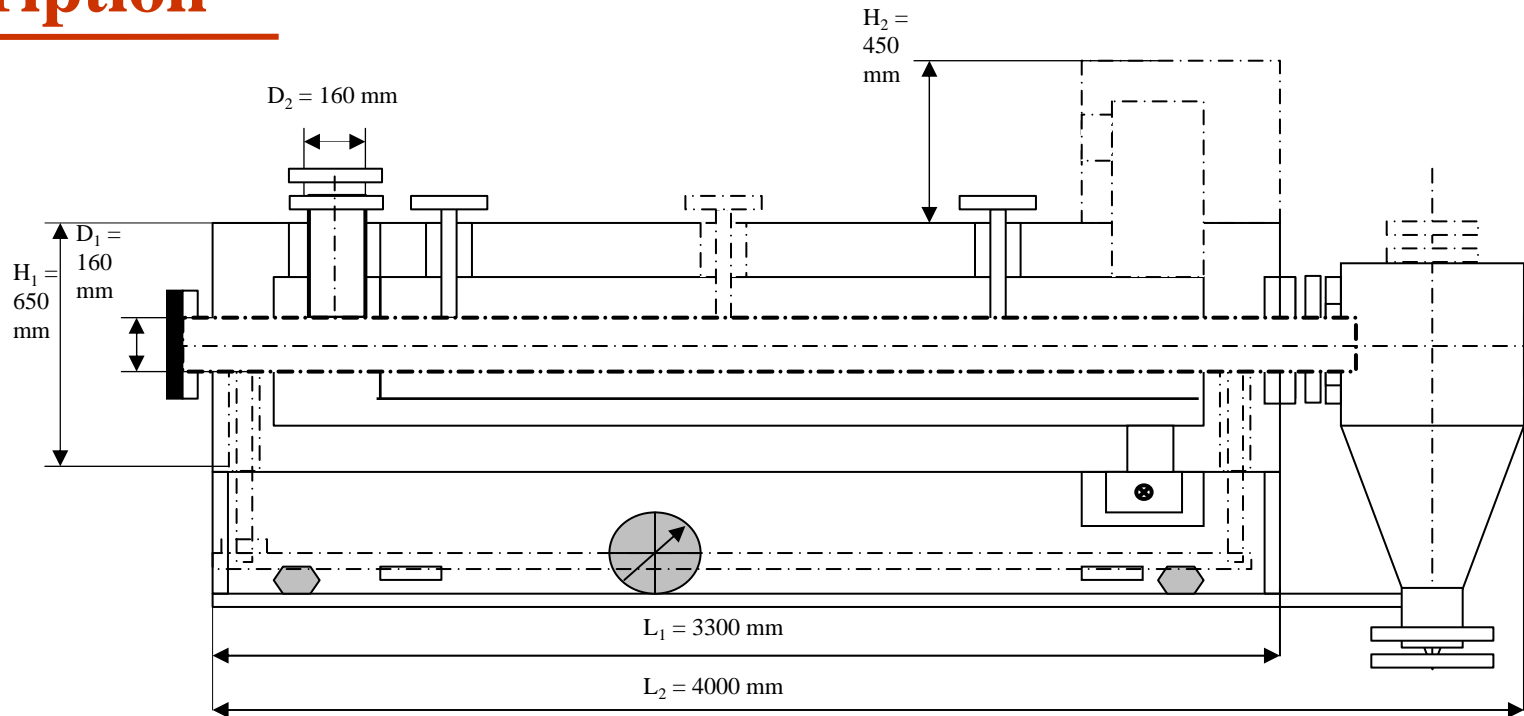
1	Biomass type Biomass pretreatment	Affects char properties, can reduce char yield, opportunities for low cost biomass.
2	Drying	Costly. 20 -30 % preferred
3	Feed size and shape	Reduced size preferable, 5 to 30 cm, unless traditional hearth technology
4	Reactor configuration	Wide variety. Scale & cost important
5	Reactor operating conditions	Pressure & heating rate important char yield increase with pressure & very slow heating rate 8 bars
6	Heat supply to reactor	Endothermic. Heat source and transfer important, most technologies are partial combustion.
7	Smoke energy recovery	Largely sufficient for wood drying and potential for small scale power generation
8	Char recovery	Minimise cooling time, hot discharge

CHARCOAL PRODUCTION IMPROVEMENT

① Low cost biomass (small particles residues) implies higher tolerance towards quality (availability & cost)

- Homogeneity of the treatment
- Appropriate control of the temperature
- More efficient technology
- **vibro-fluidized bed reactor to assure an independent relation between particle size (density) and end product quality**

description



- Heat supply by hot flue-gases circulation in an external envelope along the tubular reactor.
- Counter-current versus solid flow.
- Piston flow reactor

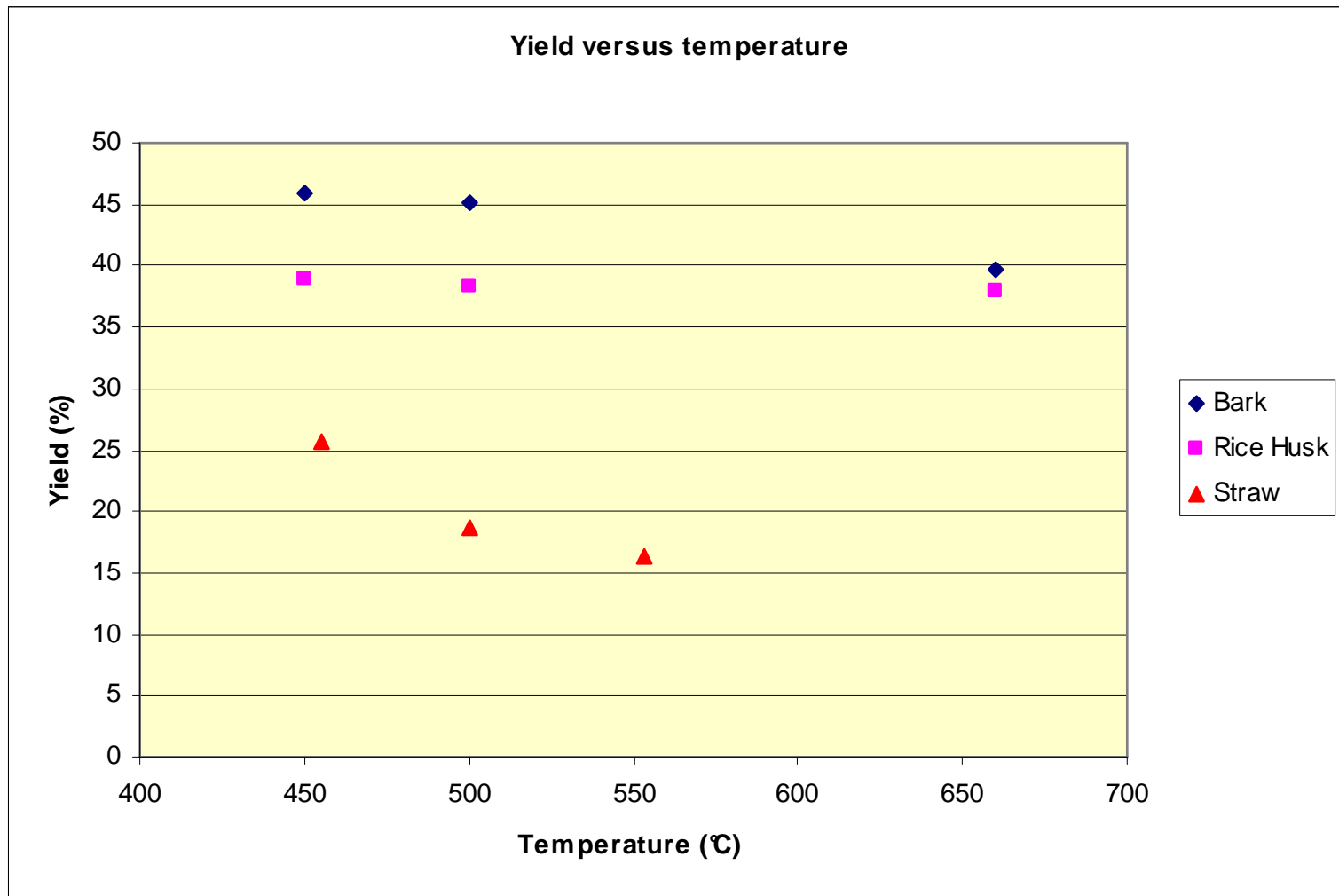
Pilot views



Sustainable charcoal production, trade & use in Europe

5-6 June 2007, Zagreb, Croatia

Pyrolysis results (residence time 135 s)



CHARCOAL PRODUCTION IMPROVEMENT

⑤ Pressurized pyrolysis

- Char yield up to 45 dw% (80 % fc)
energy efficiency 70 -75%
- Semi continuous process for energy efficiency
- More capital intensive technology
- Opportunity as energy carrier (biofuel market)

CHARCOAL PRODUCTION IMPROVEMENT

⑤ Pressurized pyrolysis

- Appropriate pressure between 4 to 8 bars
- Final temperature 450 °C and minimum residence time function of temperature and pressure to get appropriate fixed carbon content
- Pressure increase heat transfer – reduce drastically the time required for carbonisation (factor of 2 to 3)
- Increase productivity per volume of reactor

CHARCOAL PRODUCTION IMPROVEMENT

⑦ Smoke incineration



Relatively constant combustible gas quality

Steady incineration process with limited external energy

Require scheduling operation to allow non stop operation and minimize installing gas treatment capacity

loading

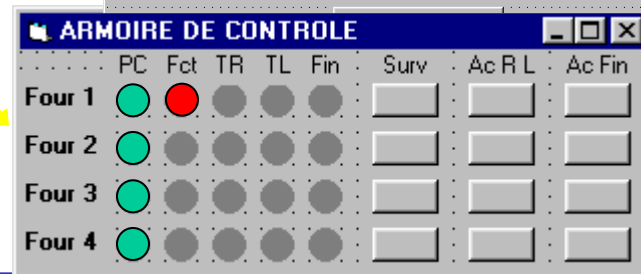
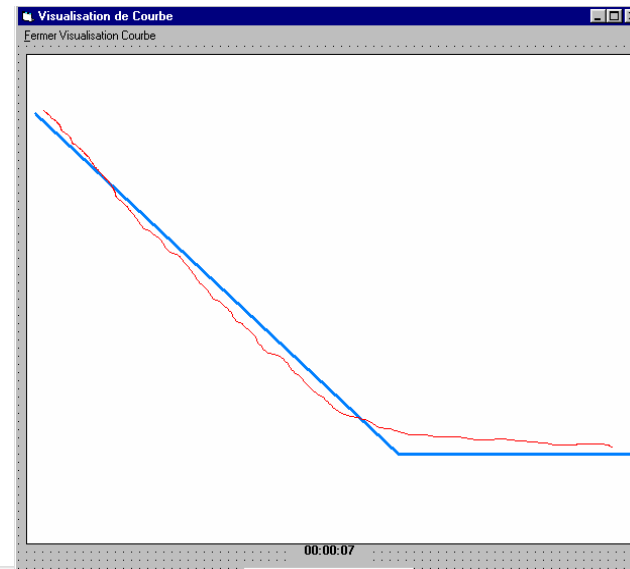
Air control

CHARCOAL PRODUCTION IMPROVEMENT

⑦ Continuous process control



Mass loss monitoring



MARKET OPPORTUNITIES

Chemicals recovery

%	BT 1	BT 2	BT 3	BT 4	BT 5	BT 6	BT 7	BT 8	BT 9	BT 10	BT 11	BT 12	BT 13	BT 14
Identified peaks	65.7	68.5	74.0	70.3	75.7	74.2	61.5	70.6	75.4	72.8	78.4	71.7	70.4	72.3
Unknown peaks	34.3	31.5	26.0	29.7	24.3	25.8	38.5	29.4	24.6	27.2	21.6	28.3	29.6	27.7
Compound groups (wt. %), based on wet oil														
Acids	4.4	8.8	3.8	3.4	3.4	4.2	3.5	4.1	7.2	2.8	3.2	3.0	4.9	5.7
Alcohols	0.5	0.5	0.2	0.3	0.0	0.0	0.1	0.0	0.6	0.2	0.1	0.3	0.1	0.4
Aldehydes	6.0	4.0	7.0	6.5	1.4	3.8	2.1	0.9	3.9	7.0	5.1	6.1	5.9	5.3
Aromates	0.1	0.1	0.3	0.0	0.0	0.0	0.4	0.3	0.3	0.3	0.0	0.0	0.0	0.3
Furans	1.6	1.1	1.9	1.5	1.5	1.4	1.4	2.3	2.0	2.2	3.0	2.4	2.0	1.4
Guaiacols	1.9	0.5	3.6	4.3	2.6	1.9	1.7	8.1	1.8	4.2	3.9	3.2	1.8	2.8
Ketones	3.1	2.7	3.8	3.8	4.0	3.4	2.9	5.5	4.1	3.5	5.8	4.3	4.5	4.6
Phenols	0.4	0.4	0.3	0.2	0.2	0.3	2.2	2.3	0.3	0.4	0.2	0.6	1.1	0.5
Pyrans	0.0	0.0	0.1	0.1	0.3	0.0	0.0	0.0	0.1	0.1	0.4	0.5	0.7	0.3
Sugars	4.0	3.0	5.2	4.2	13.1	6.6	5.7	1.1	3.4	4.6	5.7	5.9	5.3	3.6
Syringols	0.0	0.3	0.4	0.1	0.0	0.0	1.6	0.0	3.3	0.2	0.0	0.0	1.6	2.2
Others	0.1	0.0	0.1	0.1	0.9	0.6	0.0	0.5	0.0	0.1	0.6	1.4	0.8	0.6
Total	22.3	21.5	26.9	24.5	27.5	22.0	21.6	25.1	26.9	25.7	27.8	28.1	28.7	27.8

Opportunity for increasing market (medium to long term option - petrol substitute)

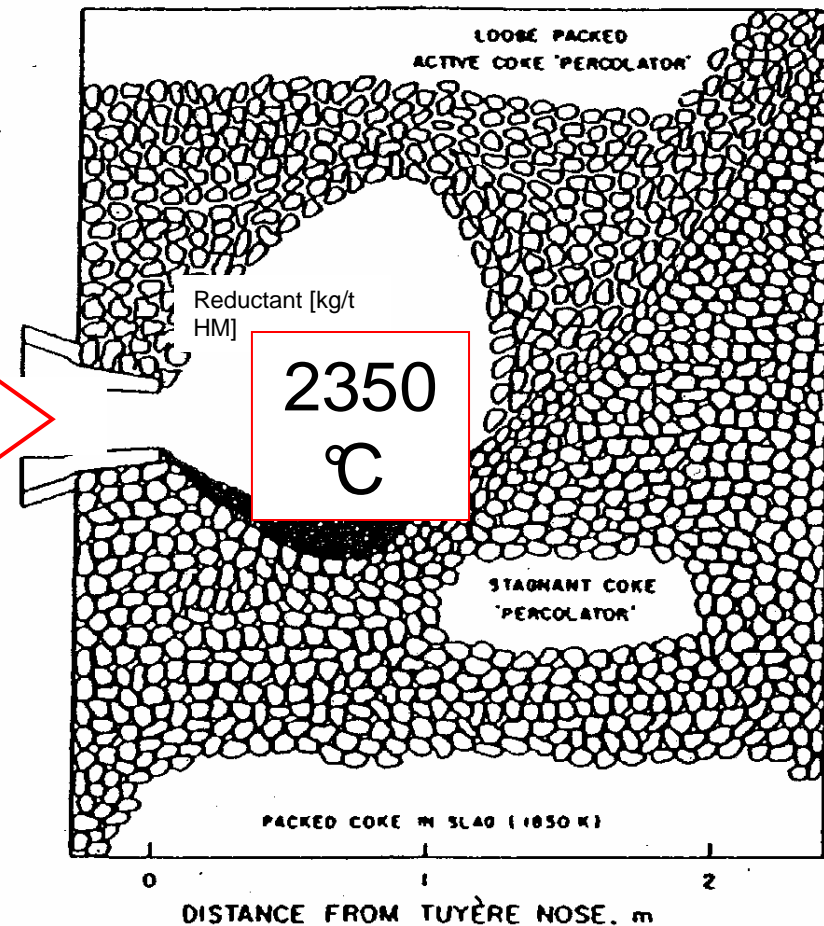
CHARCOAL MARKET OPORTUNITIES

5) Coke substitution in blast furnace steel industries ULCOS

❖ Combustion of Coke in the raceway leads to temperatures of 2350 °C (RAFT = Raceway adiabatic flame temperature)

Hot blast: 1200 °C

- ❖ Injection of reductants may decrease RAFT due to
 - ❖ Heating reductant
 - ❖ Chem. reaction to C and H
- ❖ **Charcoal shows the same properties than coke large CO₂ emission reduction**



CHARCOAL MARKET OPPORTUNITIES

CDM eligibility

Smoke incineration result in limited CO₂ emission reduction despite CH₄

However

	Inefficient technology	Improved technology
Charcoal yield (%)	15	30
Charcoal production (kg)	150	300
Charcoal carbon content (kg)	0,9 x 150 =135	0,9 x 300= 270
Carbon loss to the atmosphere (kg)	500-135 = 365	500- 270 = 230

Balance

135 kg of carbon /t of wood

450 kg C /t of charcoal