Mitigation of Greenhouse Gas emissions in the Steel Sector

Jean-Pierre Birat, ArcelorMittal-Maizières, France

Menu

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- Steel & the Greenhouse Effect
- strategies for the future: the European ULCOS program
- biomass in tropical countries & elsewhere
- a worldwide search for dedicated land: top down & bottom up evaluations
- carbon-neutrality & sustainability of plantations
- other views & conclusions

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Steel & the Greenhouse Effect

Steel & the Greenhouse Effect

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- Steel has assets & liabilities vs. the anthropogenic GHG effect!
  - a CO_2 footprint which amounts to roughly 5% of the world's anthropogenic footprint: *Steel may be part of the problem…*
  - Steel is the key to economic growth, to a high standard of living in developed economies and to offering solutions to cut emissions in other economic sectors (energy, transportation, construction, etc.): Steel: *but is mainly part of the solutions!* Steel has a positive Social Value.
- to reduce its own footprint, the Steel industry:
  - has already cut energy use & CO_2 emissions by roughly 50% over 40 years
  - recycles steel, at the highest possible level, over & over again
  - is part of an industrial ecology system (e.g. BF slag to cement)
  - shares and disseminates technologies to generalize BATs, worldwide
  - Looks at breakthrough technologies to reach further (factor 2 targets or more).

Strategies for the future: ULCOS

Ultra Low CO_2 Steelmaking

Strategies for the future: ULCOS

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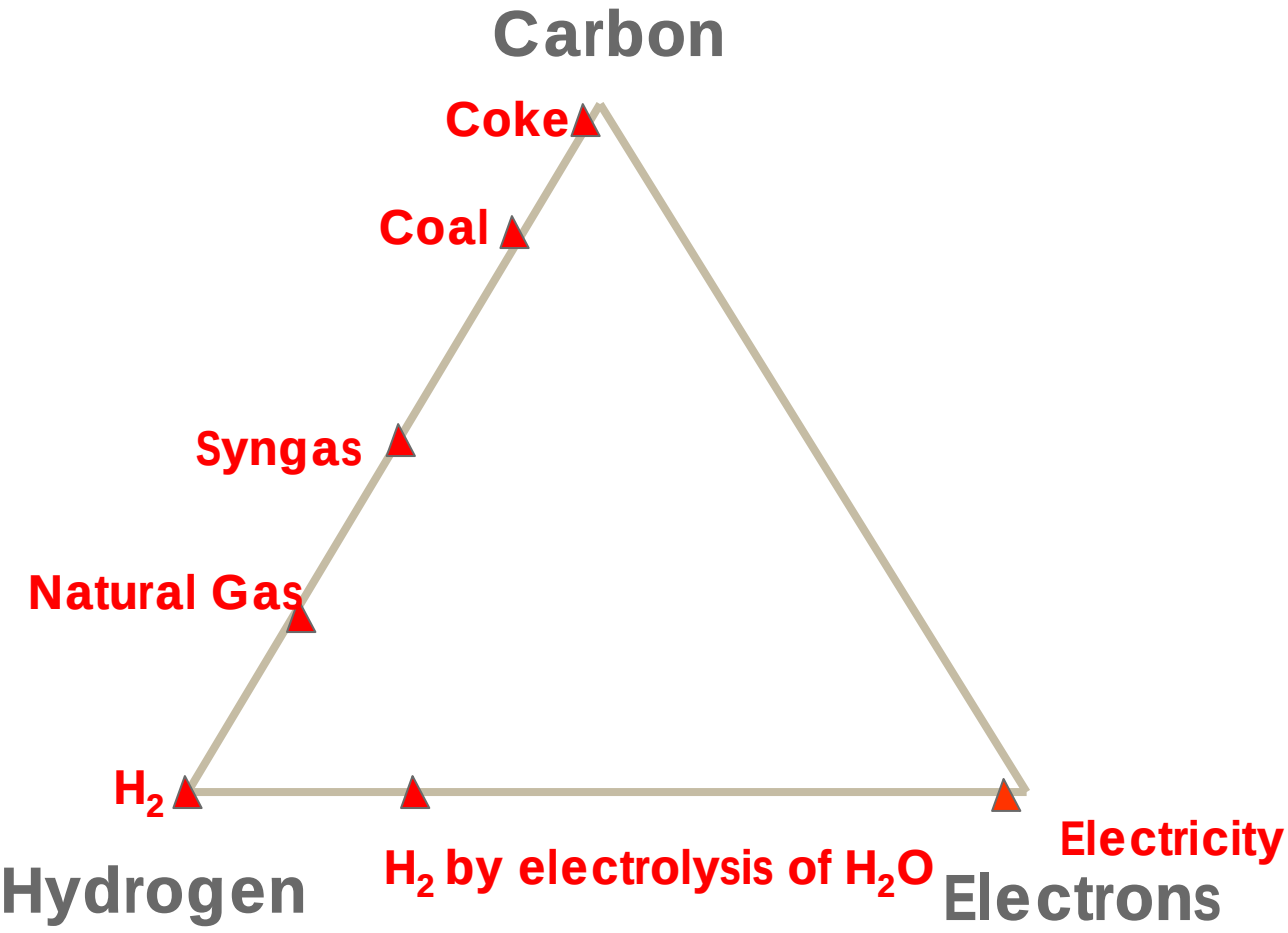
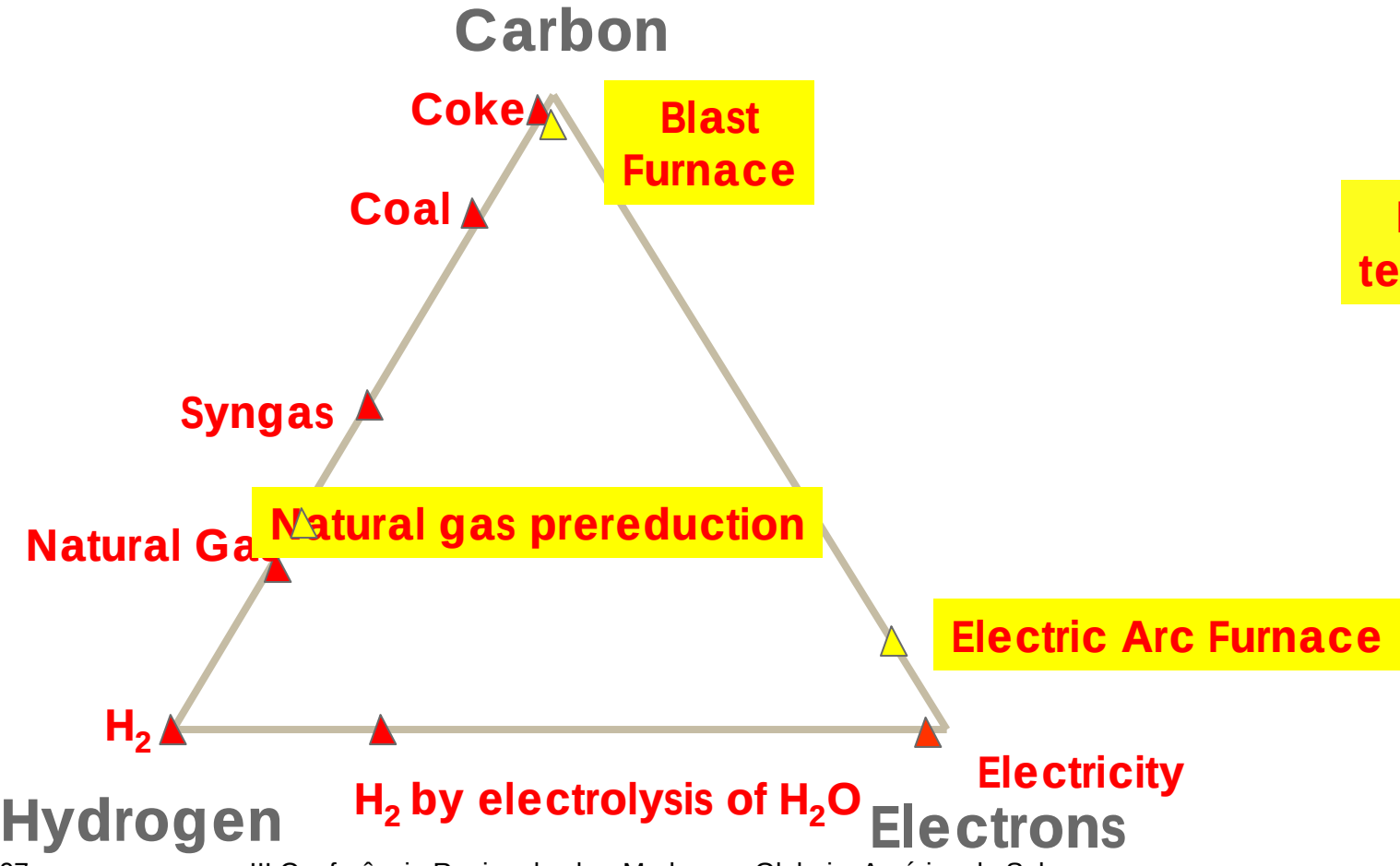
Strategies for the future: ULCOS



Strategies for the future: ULCOS



Strategies for the future: ULCOS

CO_2 capture & storage

Carbon

Coke

Coal

Syngas

al Ga

H_2

Hydrogen

Blast Furnace

Natural gas prereduction

Existing technology

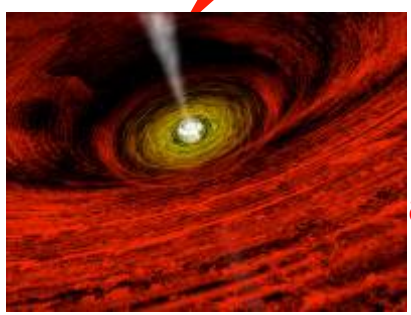
Electric Arc Furnace

Electricity

H_2 by electrolysis of H_2O

Electrons

Strategies for the future: ULCOS



CO_2 capture & storage

Carbon

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Decarbonization

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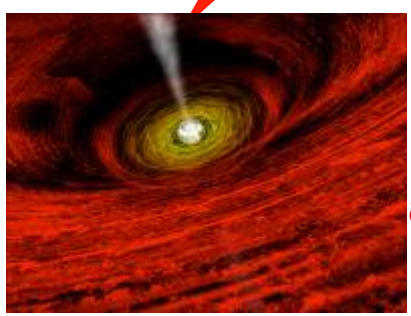
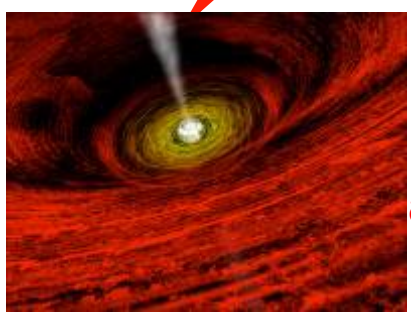


Strategies for the future: ULCOS



CO_2 capture & storage

Use of C from sustainable biomass

Carbon

Coke

Coal

Blast Furnace

Plasma in Blast Furnace

Syngas

Natural gas prereduction

al Ga

H_2 prereduction

H_2

Hydrogen

H_2 by electrolysis of H_2O

Electrons

Electricity

Electrolysis

Electric Arc Furnace

Decarbonization

Existing technology

New Technology

Strategies for the future: ULCOS

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Energy, Oxygen

ECN Energy research Centre of the Netherlands

Centro Sviluppo Materiali S.p.A.

DANIELI CORUS

STATOIL

CRM

Institutes

labein tecnalia

IVA ILVA

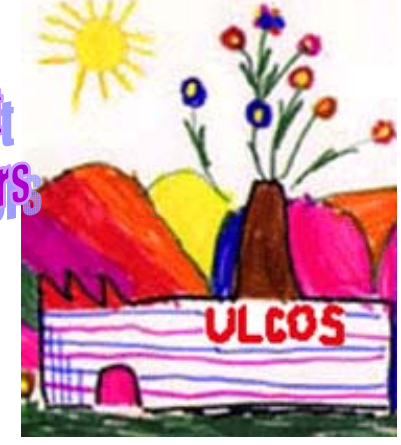
KÜTTNER Engineering and Contracting

MEFOS

ipts

voestalpine

Equipement manufacturers



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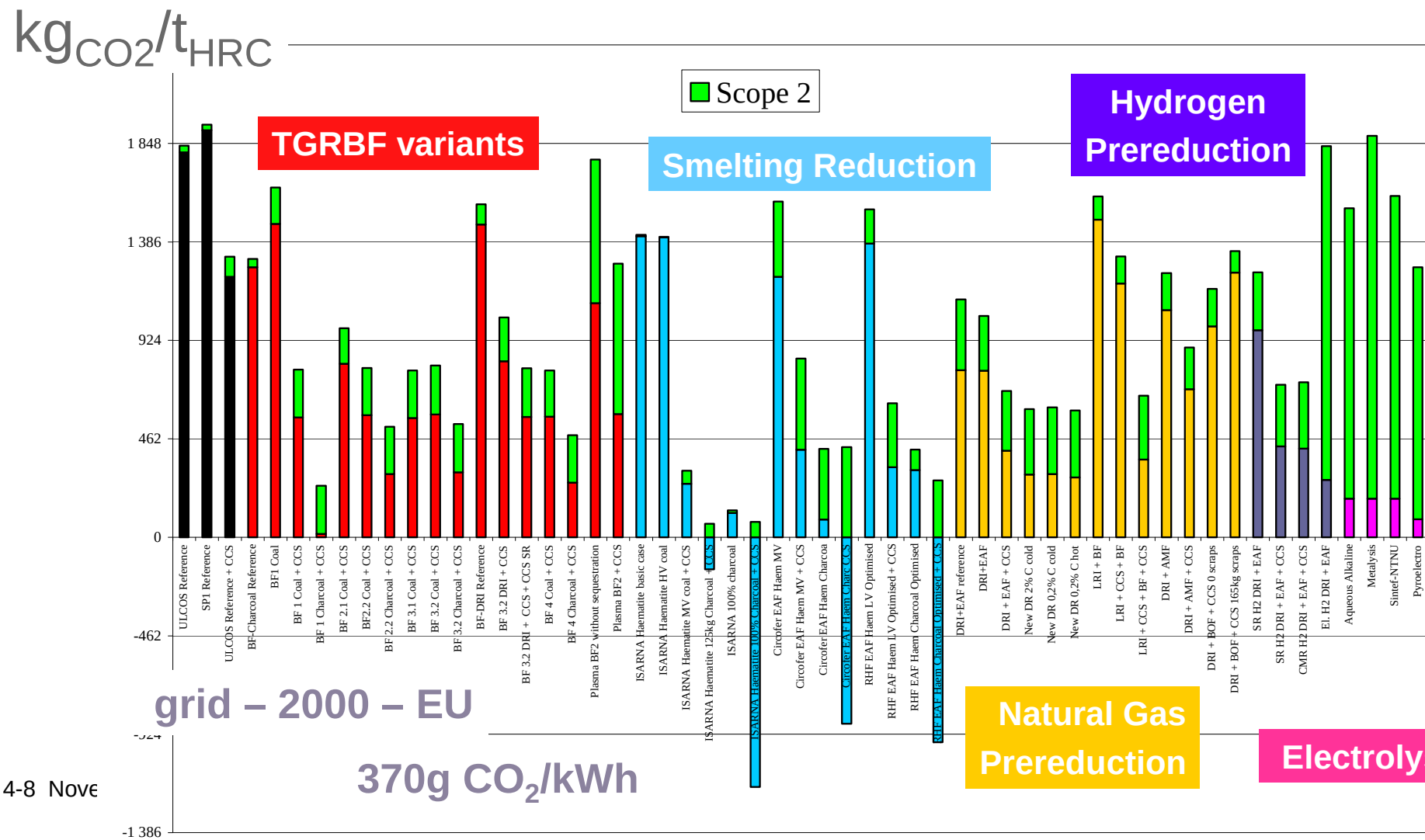
Strategies for the future: ULCOS



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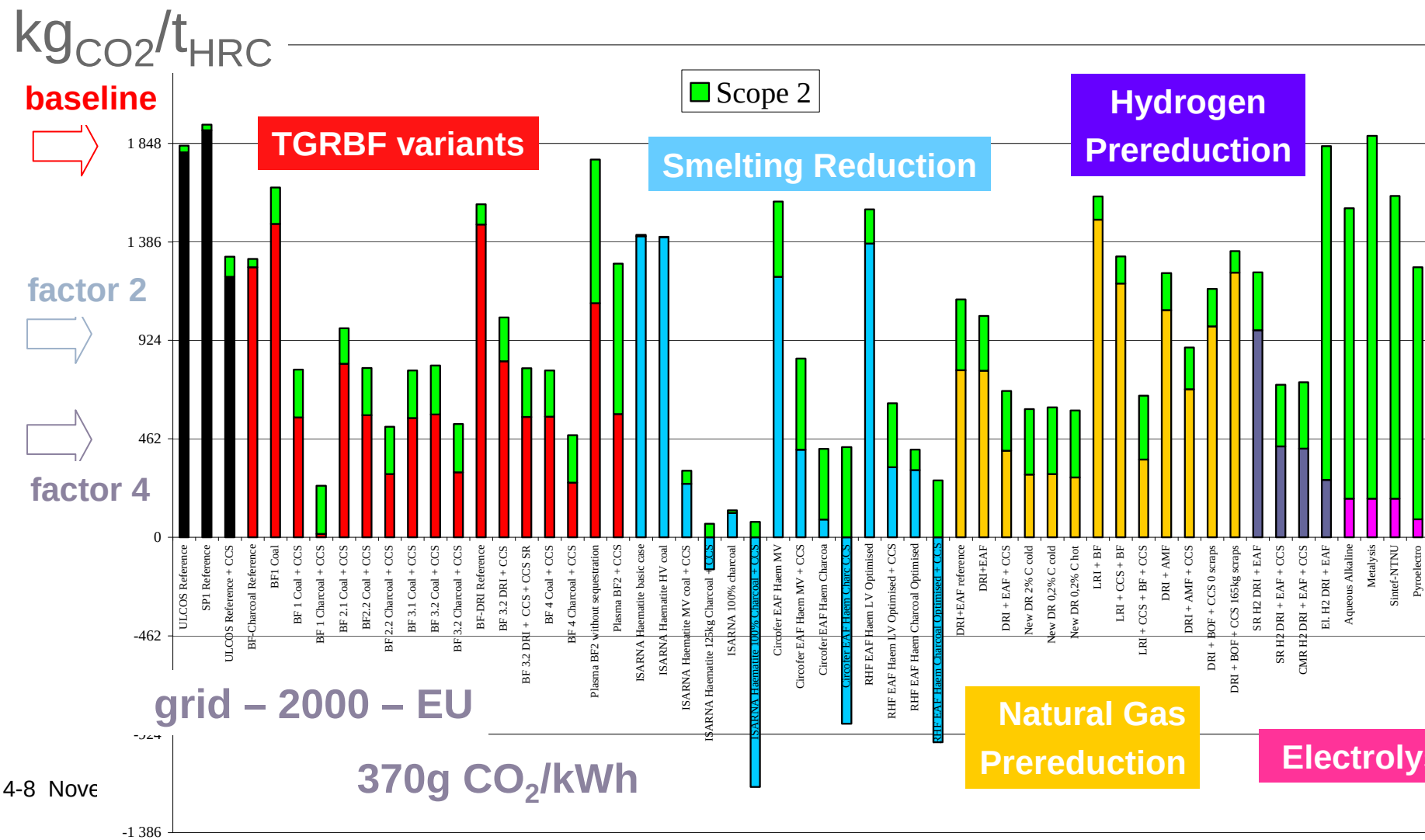

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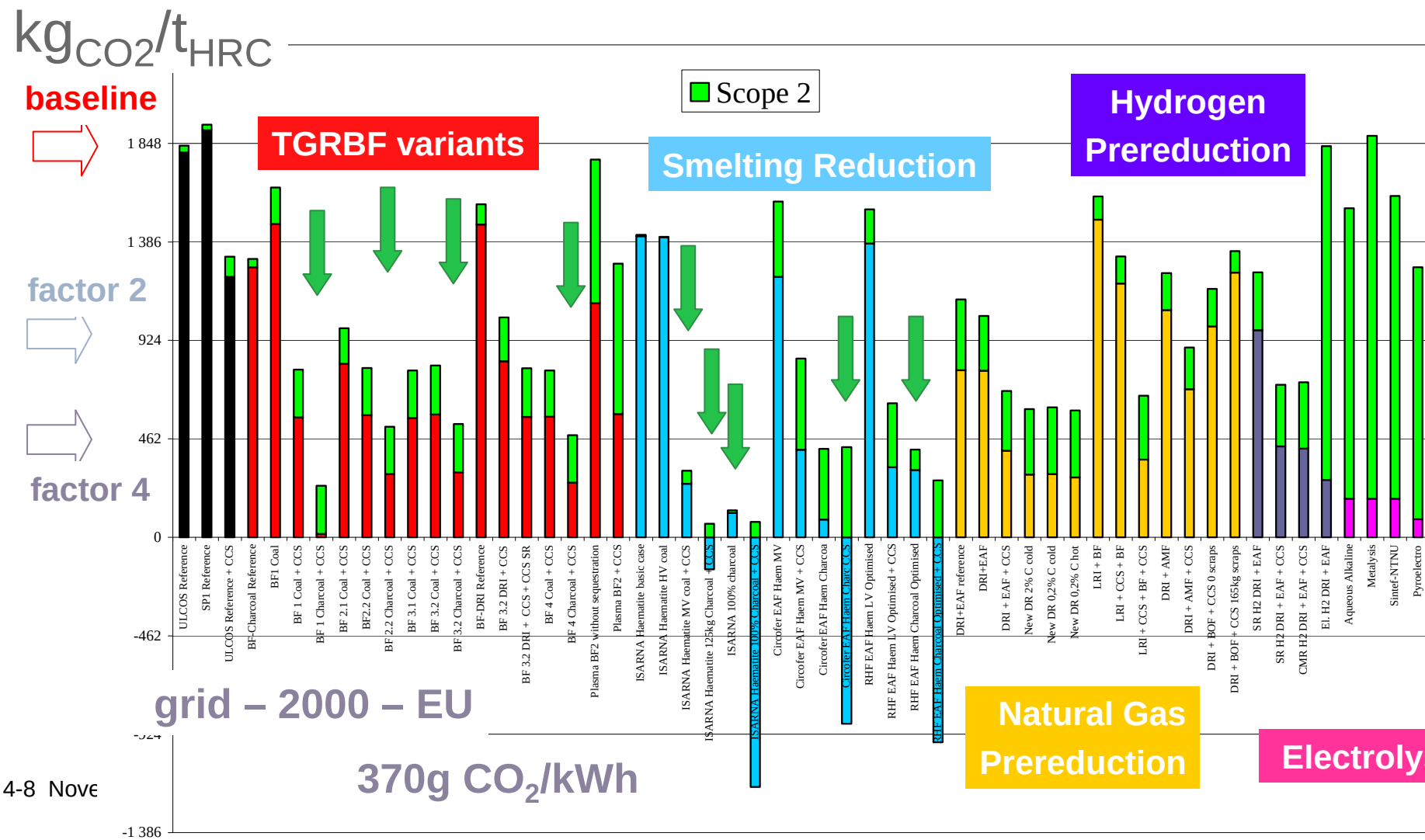

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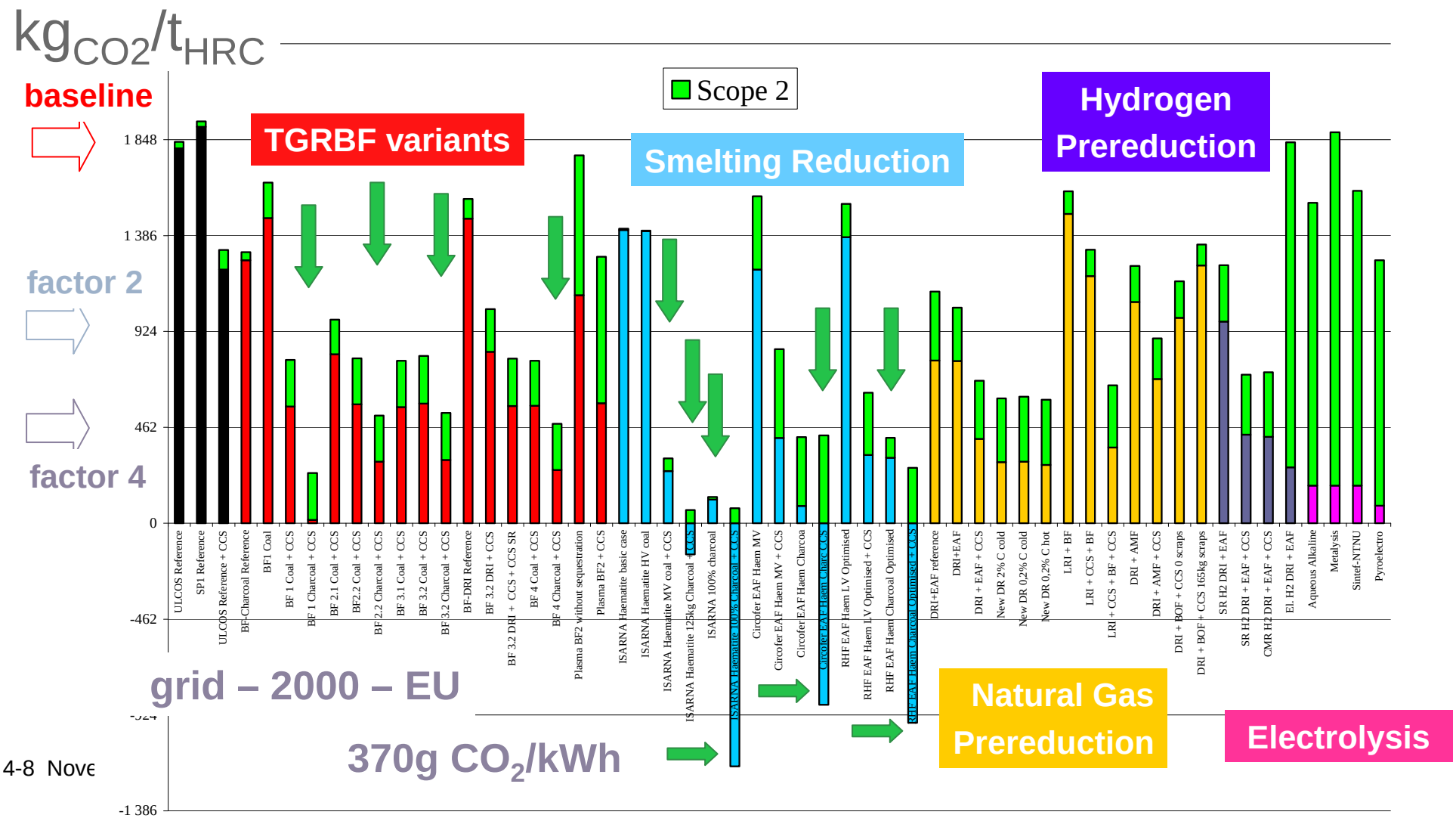

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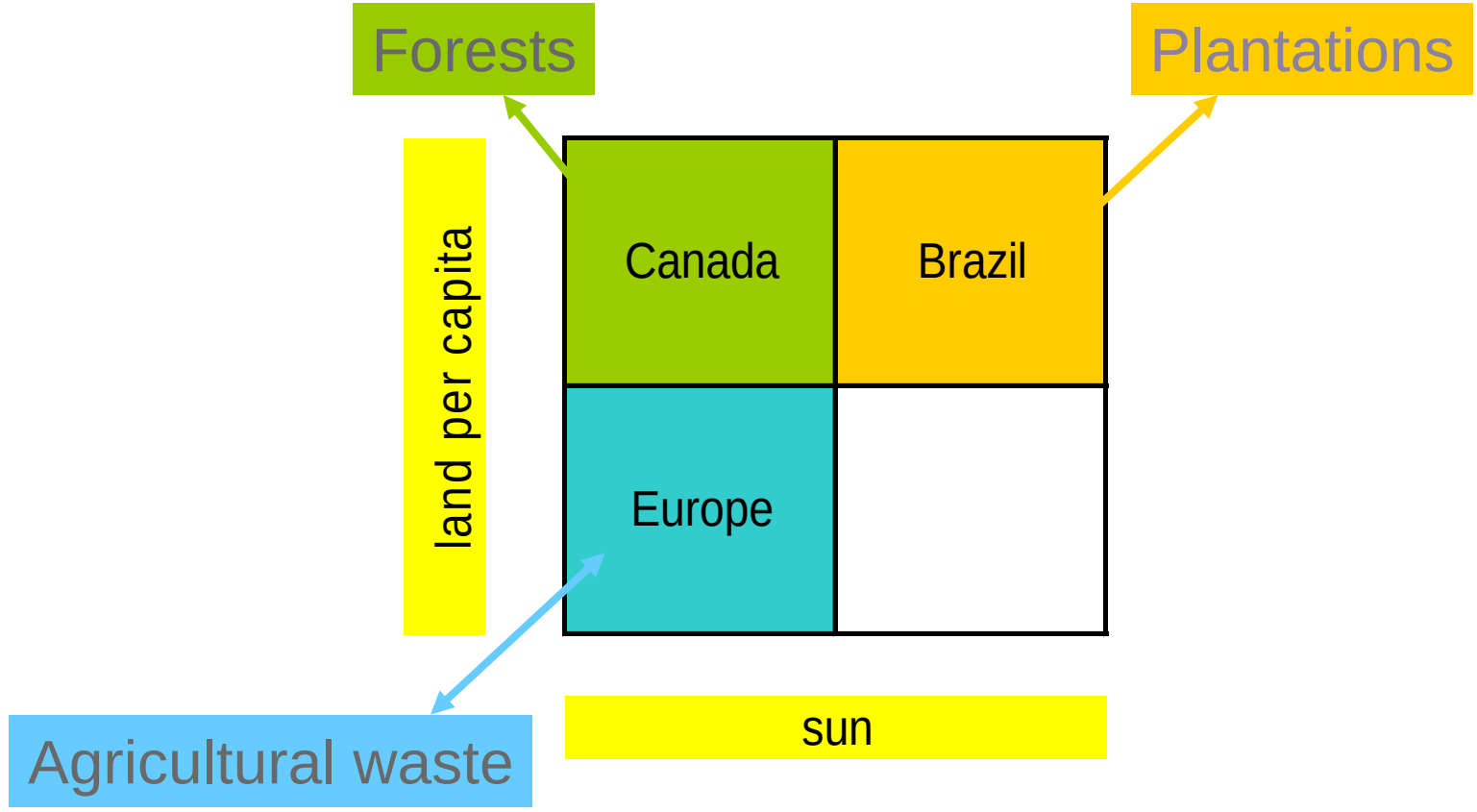
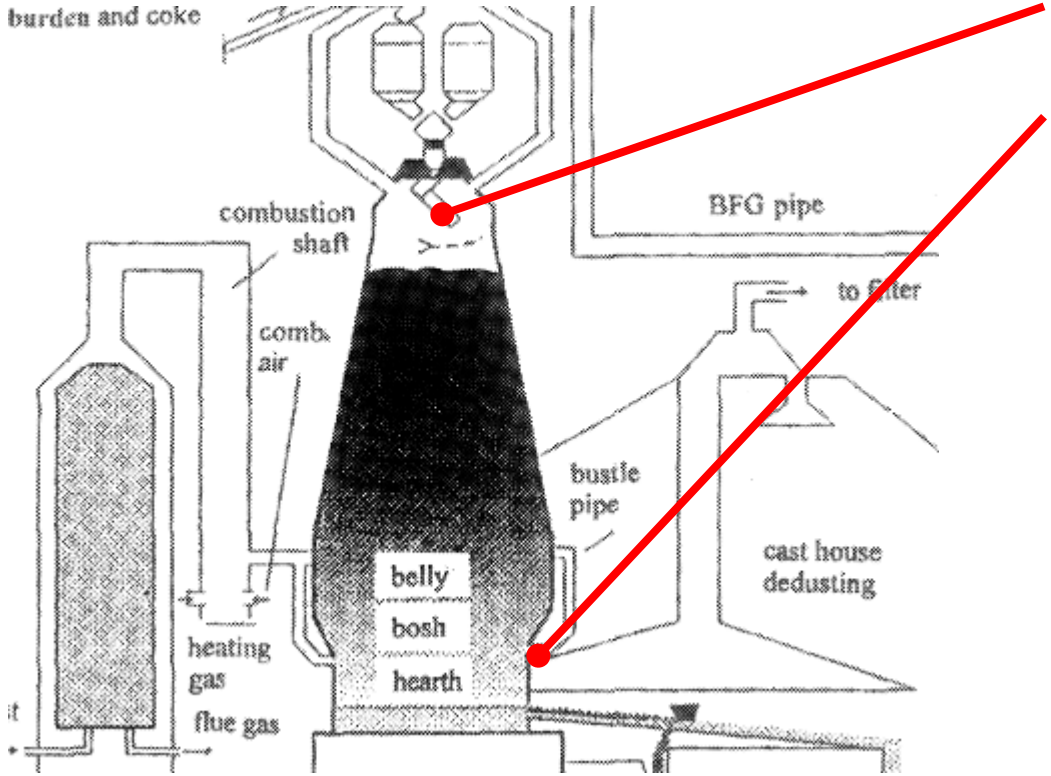
Biomass in tropical countries & elsewhere

Biomass in tropical countries & elsewhere

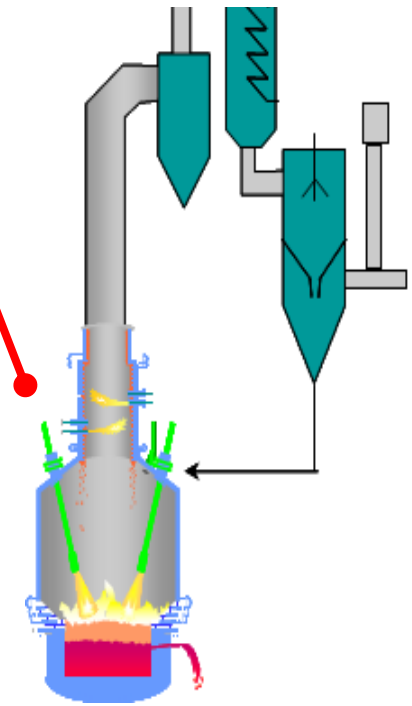


Using charcoal…..



Coke substitute in small BF, not possible in large ones

Pulverized coal substitute (BF, Smelting Reduction)



Needs for the EU's Steel industry

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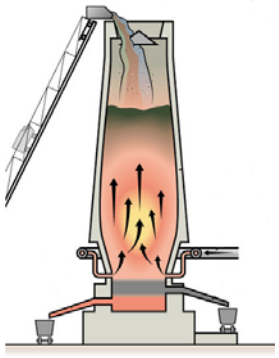

1 t hot metal consuming

0.450 t $_{FC}$

Charcoal quality:
80% Fixed Carbon

Conversion yield: **30%**

Loss in handling & transportation: **10%**

1 t of pig iron consumes **2.1 t** of dry wood

50 Mt hot metal ➔ 6.5 Mha or 65,000 km²

If the productivity in plantation reaches **16 t$_{dw}$/ha.yr**

1 Mt of hot metal requires about

129,000 ha of plantation

Needs for the EU's Steel industry, tomorrow

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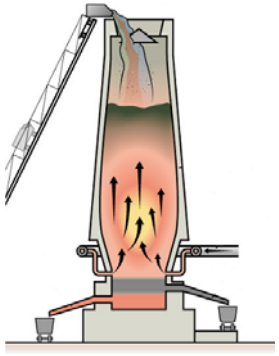
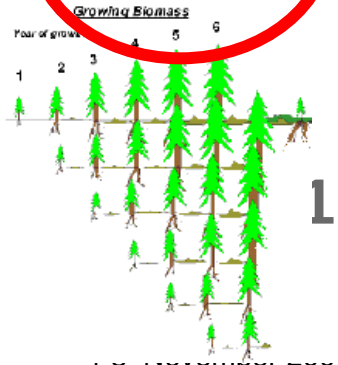


1 t of hot metal consumes

0.410 t $_{FC}$



Charcoal quality:
80% Fixed Carbon

Conversion yield: 42%

Loss in handling & transportation: 10%

1 t of pig iron consumes
1.4 t of dry wood

50 Mt hot metal ➔ 3.4 Mha or 33,600 km²

If the productivity in plantation reaches **20 t_{dw}/ha.yr**

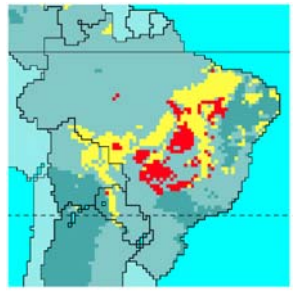
1 Mt of hot metal would require

67,000 ha of plantation

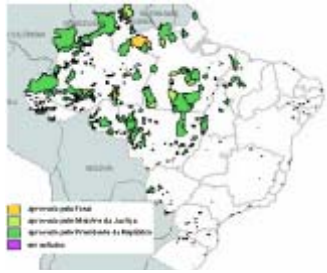

Land availability…

Land availability… (bottom-up approach)

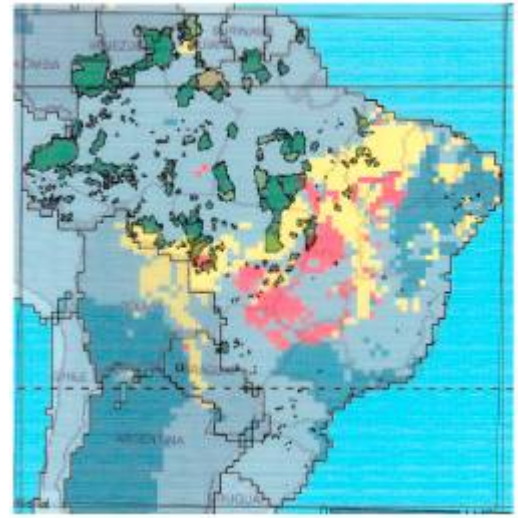
- First estimates of potentials by spatial analysis:
  in 2000 = **111 Mha** in 2050 = **74-186 Mha**
- Confrontation with local maps and data on rainfalls, population density, land cover..., + additional criteria on national regulations (Indian reserves, ...)



first estimates



protected areas



overlapping areas

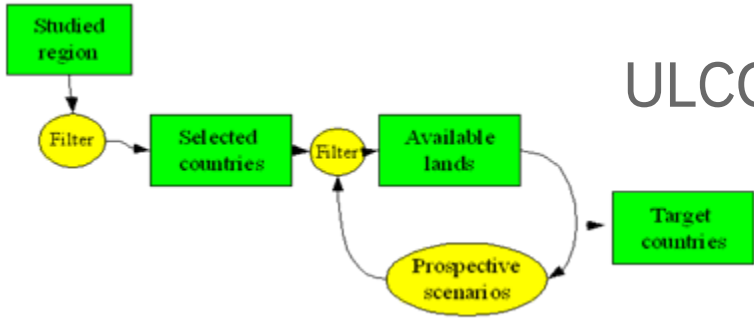
Results

2000: **77 Mha** (-33%)

+ conservative interpretation of Legal Reserve obligations: **67 Mha**

Environmental regulation is crucial in the assessment of potential land availability!

Land availability… (bottom-up approach)



ULCOS requirements: 4 to 7 Mha

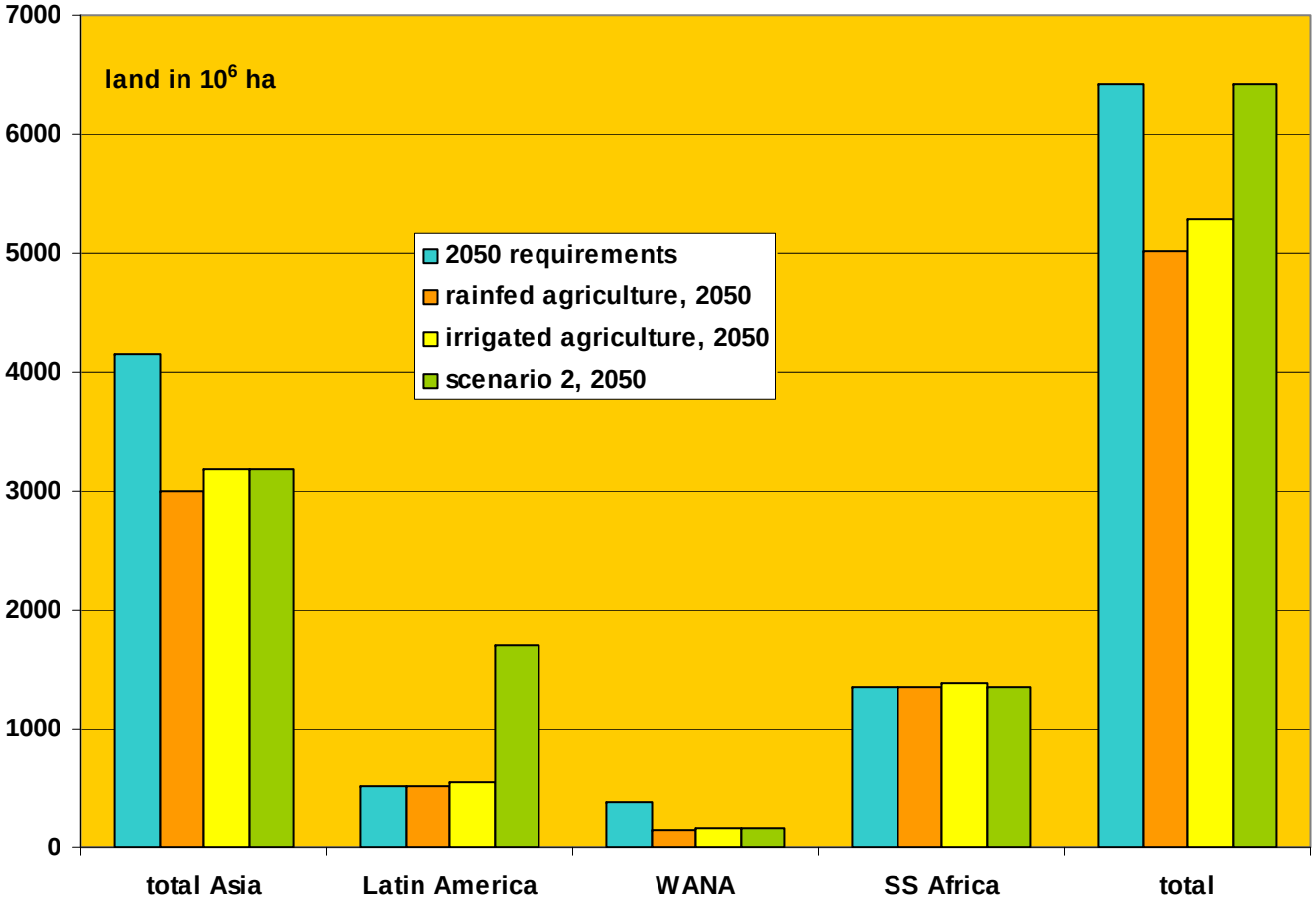
Minimum rainfall: 1000 mm

	Mha 2000		2050 B1		2050 A2	
selected countries	**total area**	**potentially available area**	**potentially available area**	**including abandonned agri-land**	**potentially available area**	**including abandonned agri-land**
in Africa	**927**	**158**	**124**	**174**	**61**	**61**
in South America	**1501**	**122**	**108**	**207**	**73**	**73**
in Asia, largo sensu	**1537**	**27**	**13**	**19**	**10**	**10**
in the Pacific	**804**	**29**	**33**	**60**	**32**	**46**
TOTAL	**4769**	**336**	**278**	**460**	**176**	**190**

A worldwide search
for land dedicated to energy crops

top-down approach

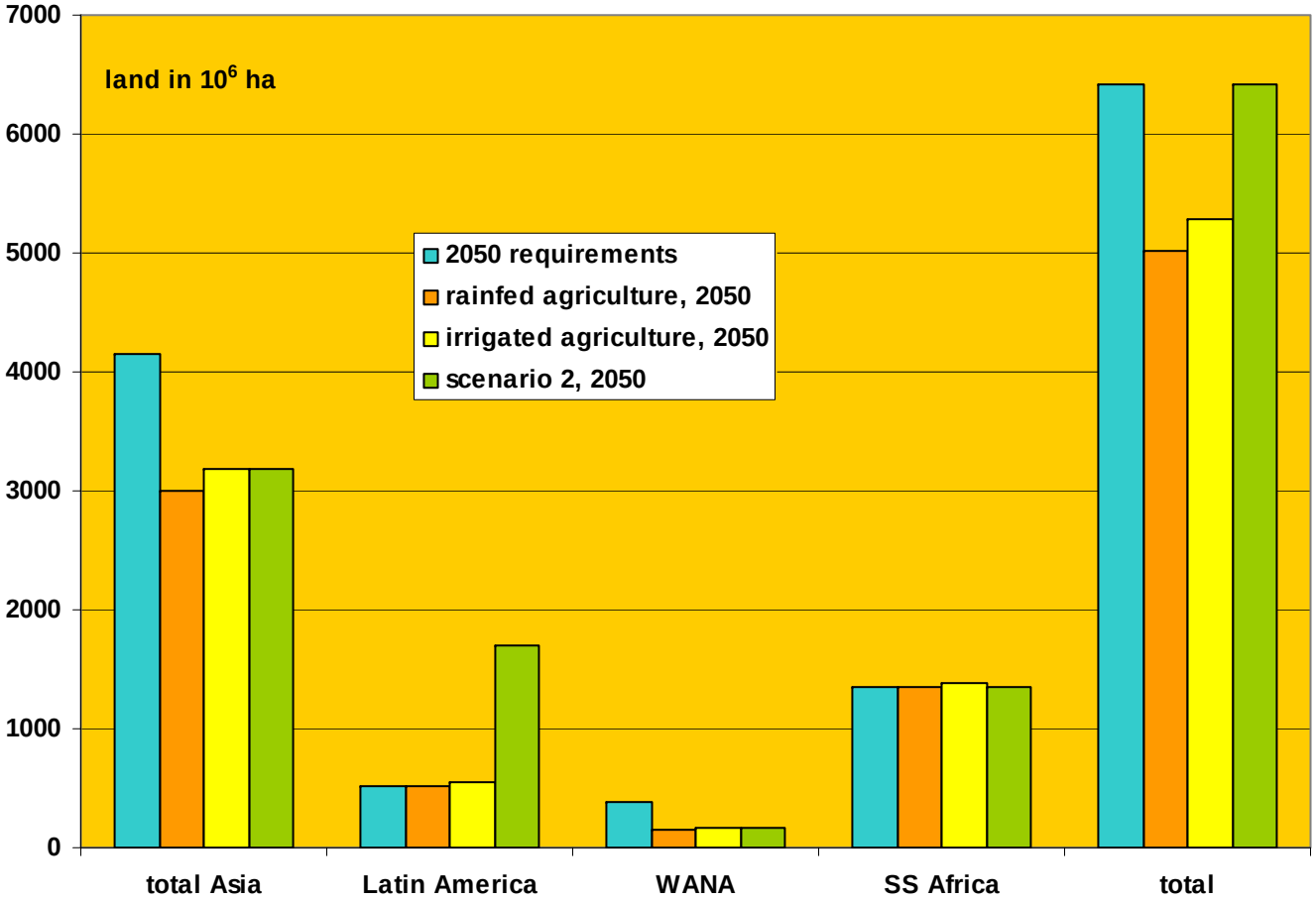
A worldwide search for land dedicated to energy crops



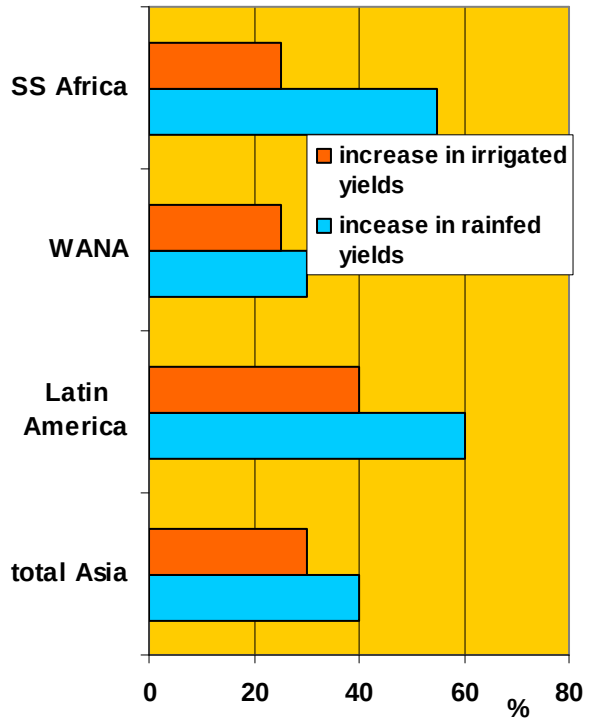
top-down approach

Michel Griffon, CIRAD, *food, fibre & energy from biomass: will the world have enough space and resources for its needs in 2050,* 2nd ULCOS seminar, Aveiro, 2005

A worldwide search for land dedicated to energy crops



top-down approach



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Carbon-neutrality & sustainability of plantations

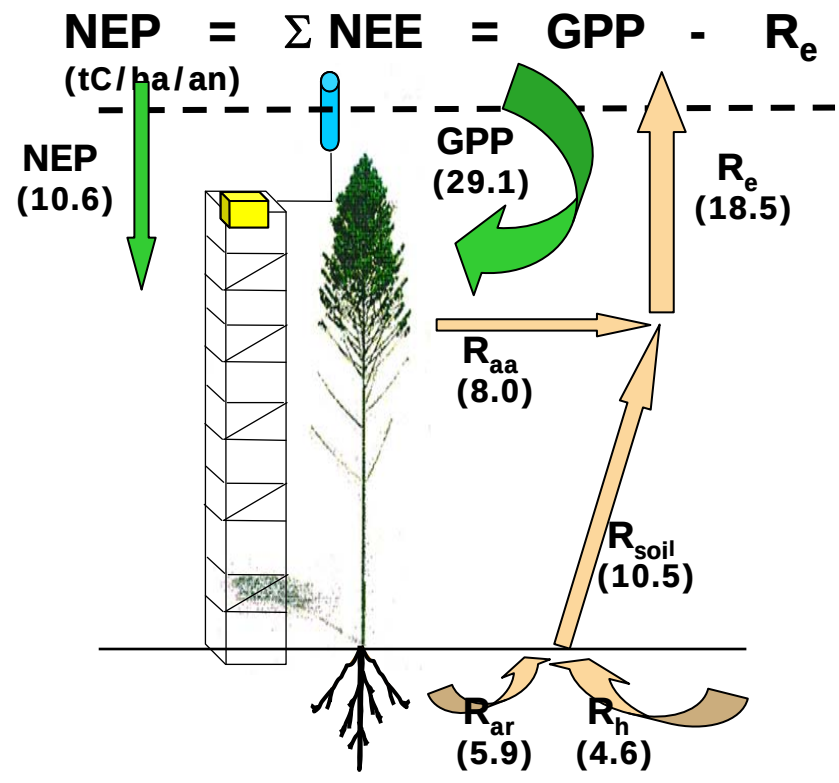
Carbon-neutrality & sustainability of plantations

Experiments are carried out to assess C sequestration and water use in eucalyptus plantations

... in order to compare alternative silvicultural practices

Carbon budget…

Assessment on a 3- to 4-year-old Stand



At harvesting

The mean amount of carbon that can be exported at the end of a seven year-rotation is estimated at 36.7 t_C (134.5 t_{CO2}) ha^{-1} which represents an average of **5.2 $t_C.ha^{-1}.year^{-1}$**

Land-use change from savannah to eucalyptus plantations

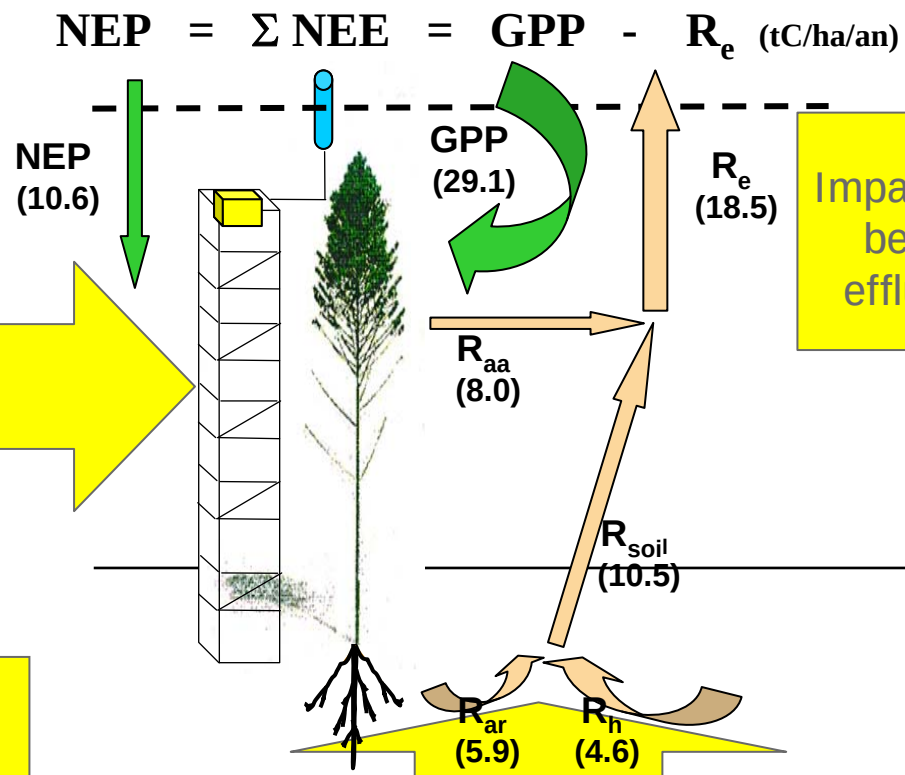
Increase in the carbon stocks of the afforested area: a total of 28.8 $t_C.ha^{-1}$ (24.4 t_C ha^{-1} in biomass, 4.4 t_C ha^{-1} in litter, and 0 t_C ha^{-1} in soils).

Sustainability: water & nutrients…






On-going experimental campaign…



Continuous measurements of fluxes of water vapor (evapo-transpiration), and CO_2 (carbon sequestration) measured by eddy-covariance

Impact of soil disturbance before planting on C effluxes and C balance

Estimating the autotrophic (root) and heterotrophic component of soil respiration is important to assess the soil carbon budget of eucalyptus plantations

Calibration of MAESTRA Model

Test two independent estimations of stand-level root respiration, and heterotrophic soil respiration, and model carbon dynamics in plantation soils

Mapping H_2O use & C sequestration in Brazil

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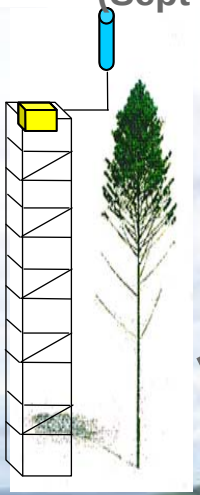
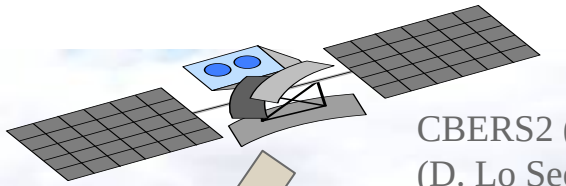
Eddy-covariance site
(Sept 2007)

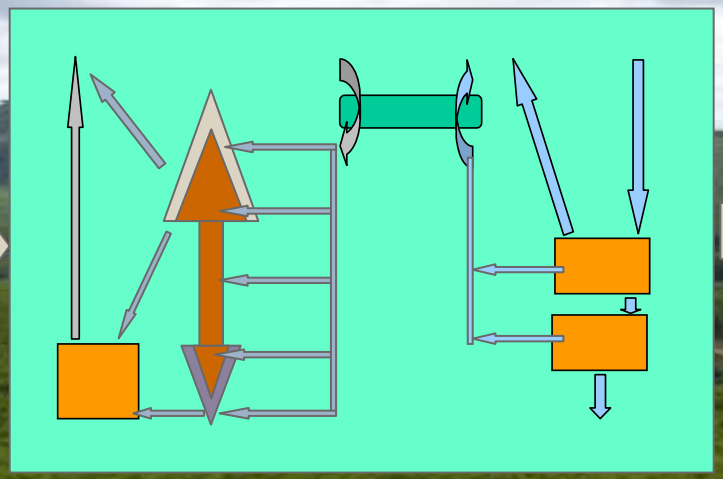


Input meteorological data



CBERS2 (20 m resolution)
(D. Lo Seen, Y. Nouvellon, C. Marsden; Sept 2007)

LAI from satellite images



Input ecophysiological parameters

Clonal experiment
(ecophysiological parameters for main planted clones)

soil maps

Weekly, monthly maps of:

- Water-use
- Production
- Carbon budget

Photo: JL Stape
5 4 2006

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Conclusions

Conclusions…?

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- biomass is a powerful solution to mitigate CO_2 emissions of the Steel Industry
- this solution is state-of-the art in Brazil, especially at ArcelorMittal Brazil, based on the technologies of eucalyptus plantations, charcoal conversion & small blast furnaces
- carbon-leanness and sustainability is exemplary!
- the extension of this model, for example to Europe, requires some paradigm shifts:
  - local (EU) biomass, e.g. agricultural waste, can most probably not be mobilized for making Steel
  - charcoal, exported from countries like Brazil, would be technically possible, if the target were to substitute pulverized coal (BF, SR furnace)
  - CO_2 emissions are only due to logistics, if the plantation is properly "managed"
  - the sustainability of the global system (carbon chain, including the downstream industrial usage) is ensured with a minimal fertilizer input, notably N

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Thank you!