Export of torrefied and non-torrefied biomass; comparison of technical and economic performance

Central European Biomass Conference
Workshop: Torrefaction of Biomass
Graz - Austria 28th January 2011 -

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Task Leader IEA Bioenergy Task 40

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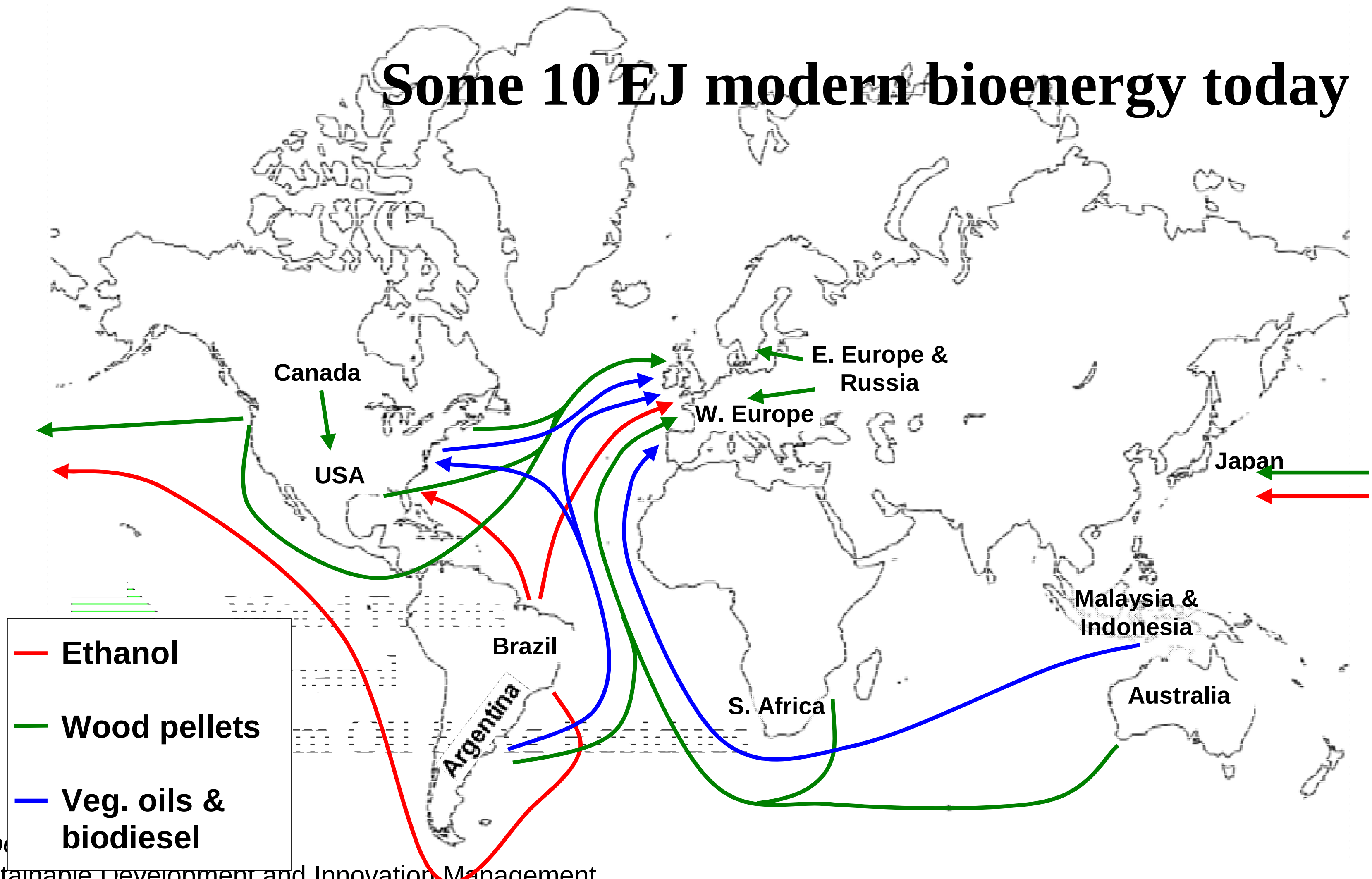
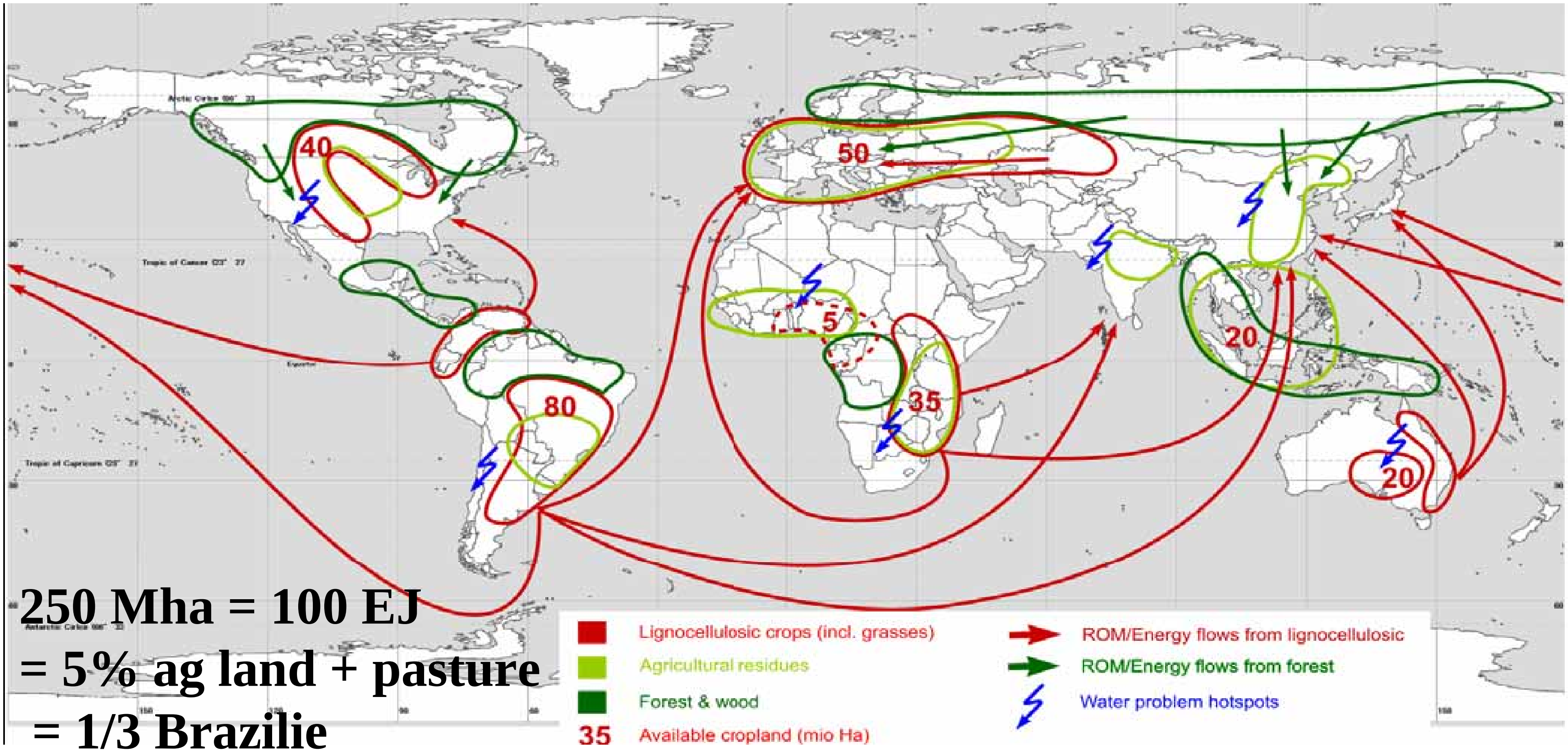
Current main Shipping Lanes for biomass and biofuels for energy



A future vision on global bioenergy markets (~200 EJ in 2050…)



250 Mha = 100 EJ
= 5% ag land + pasture
= 1/3 Brazilie

[GIRACT FFF Scenario project; Faaij, 2008]

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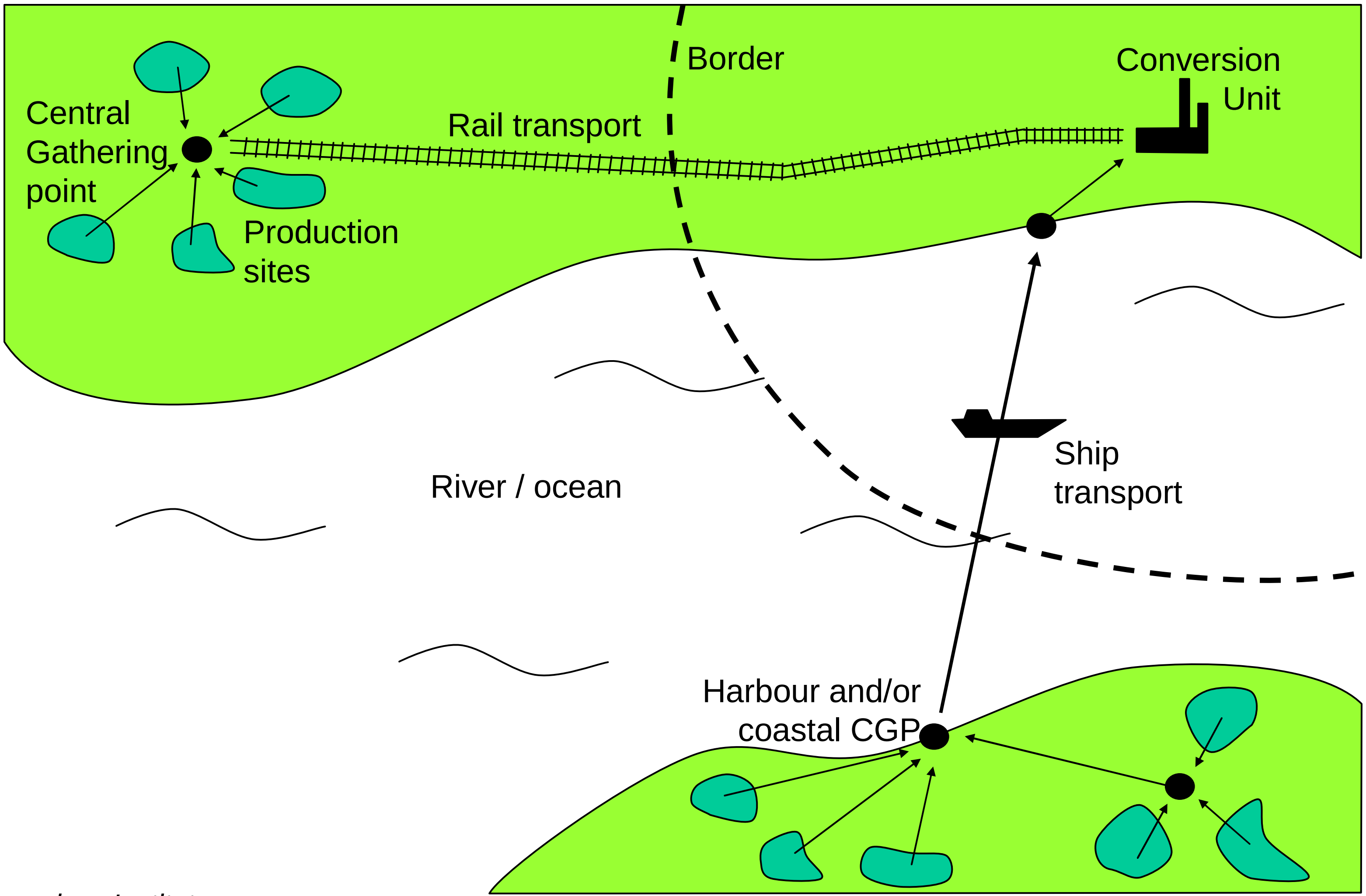
System analysis on long distance biomass supply lines.

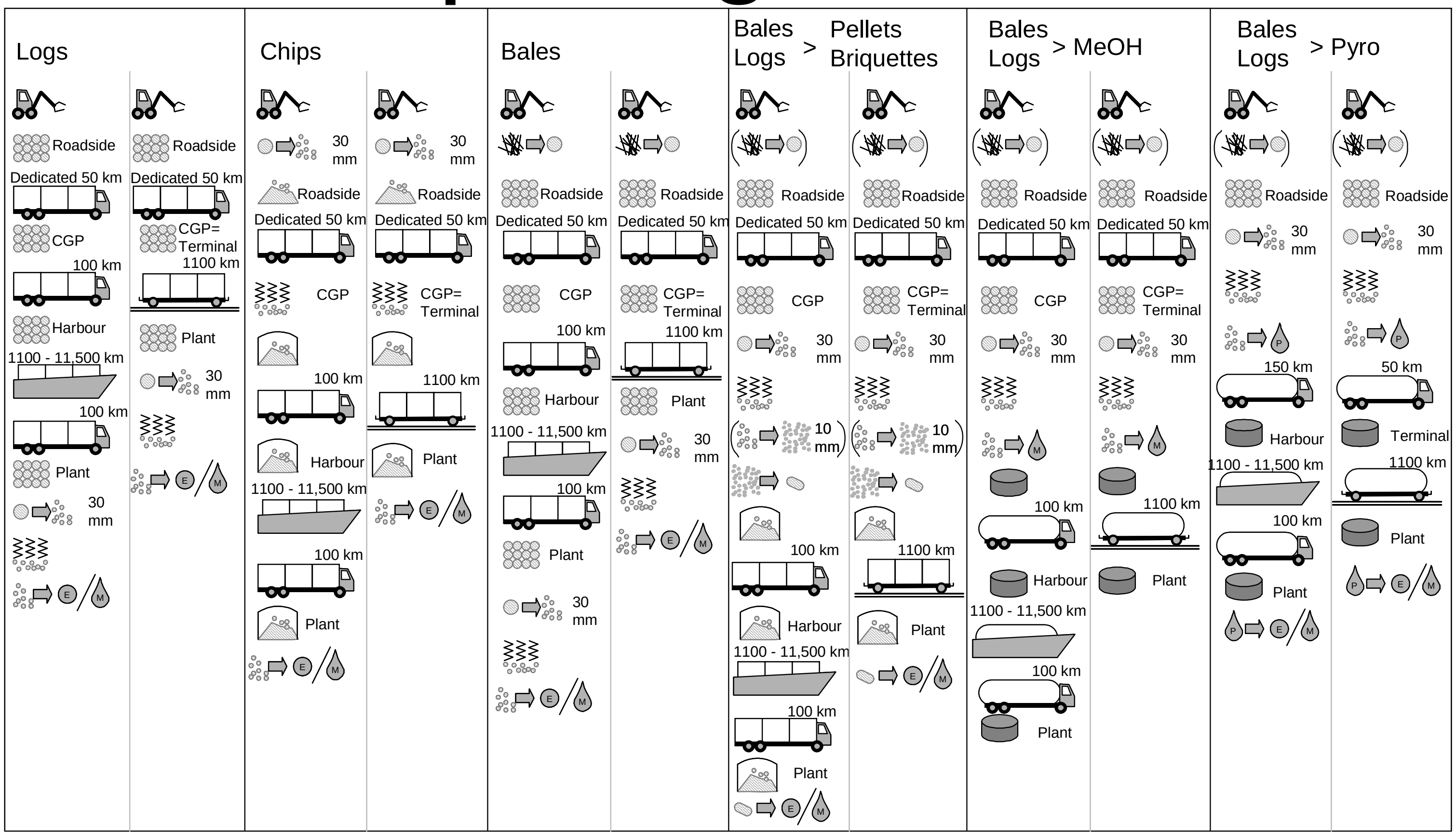
- A. Uslu, A.P.C. Faaij, P.C.A. Bergman, *Pre-treatment technologies, and their effect on international bioenergy supply chain logistics. Techno-economic evaluation of torrefaction, fast pyrolysis and pelletisation.* Energy, the International Journal, Volume 33, Issue 8, August 2008, Pages 1206-1223.
- Carlo N. Hamelinck, Roald A.A. Suurs, André P.C. Faaij, *Techno-economic analysis of International Bio-energy Trade Chains*. Biomass & Bioenergy, Vol. 29, Issue 2, August 2005, Pages 114-134
- **Key objective: Longer term outlook on long distance biomass supply lines, assuming mature and full scale deployment of technologies and biomass production systems**

International bio-energy logistics

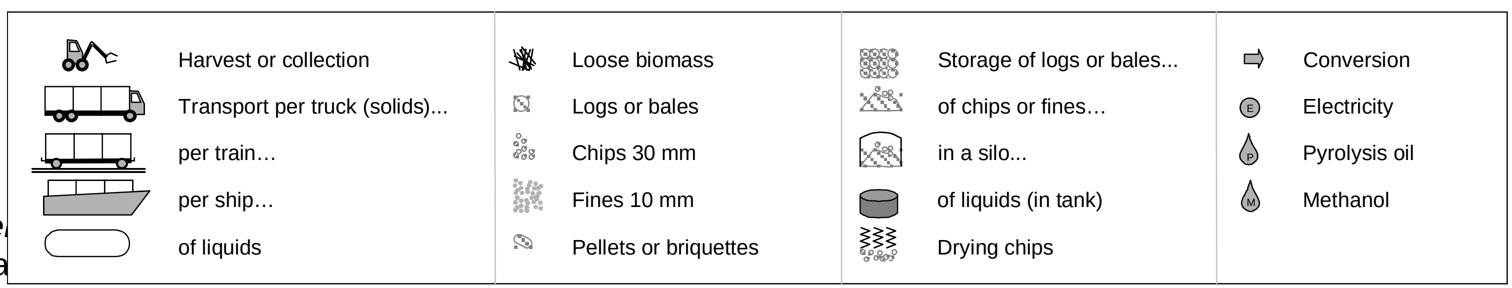


Source: Hamelinck, Faaij, 2005

Composing chains…



Legend



Source: Hamelinck, Faaij, 2005

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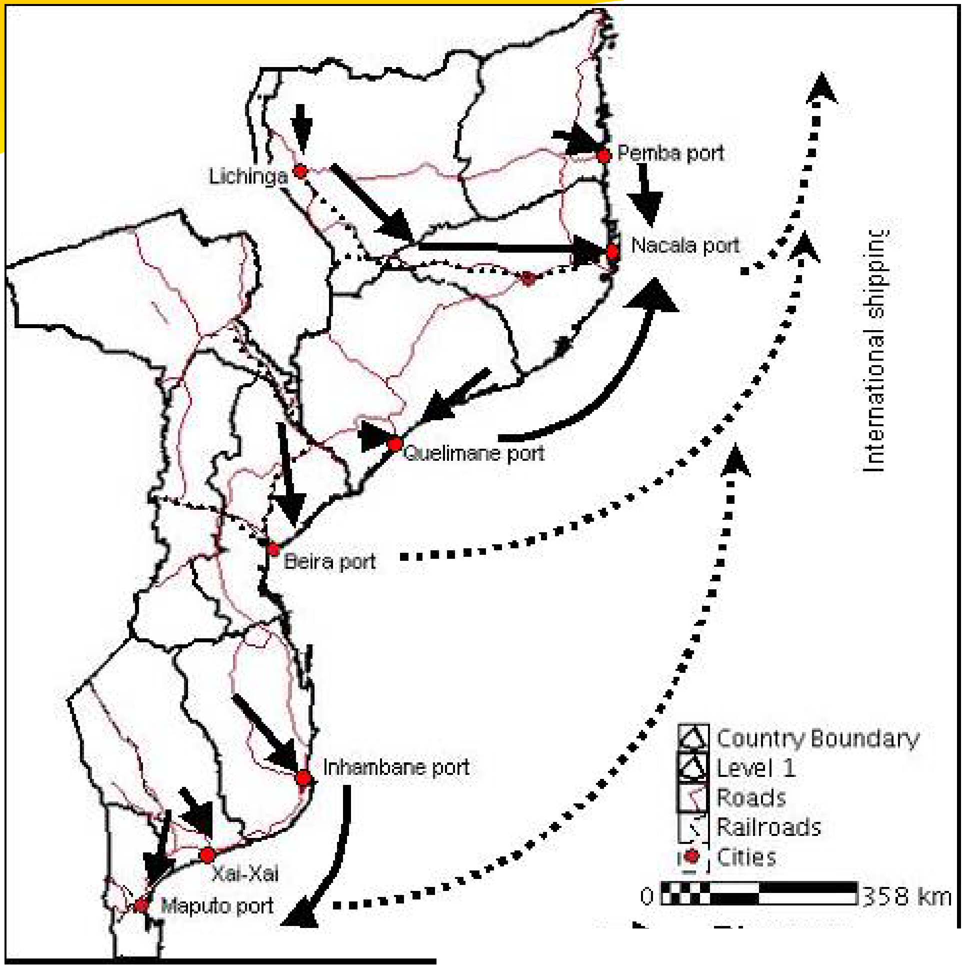
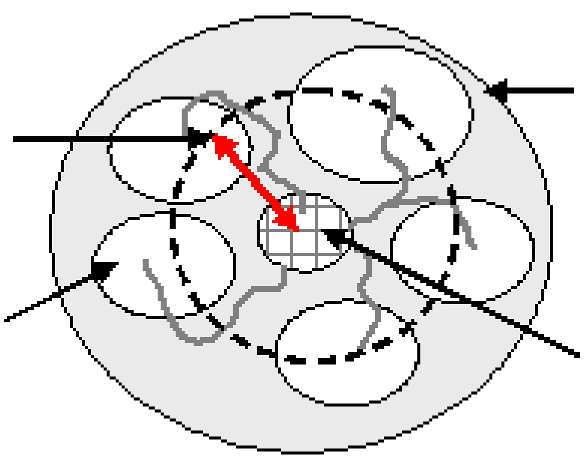
Some key findings…

- Reference systems importing & exporting country crucial for net GHG impact
- Economies of scale crucial.
- Pre-treated biomass or secondary energy carriers preferred for international transport.
- Sea transport limited impact; road transport significant.
- Region specific (biomass distribution density, transport parameters, etc.)

Logistics for export….

[Batidzirai & Faaij, Energy for Sustainable Development, 2006]





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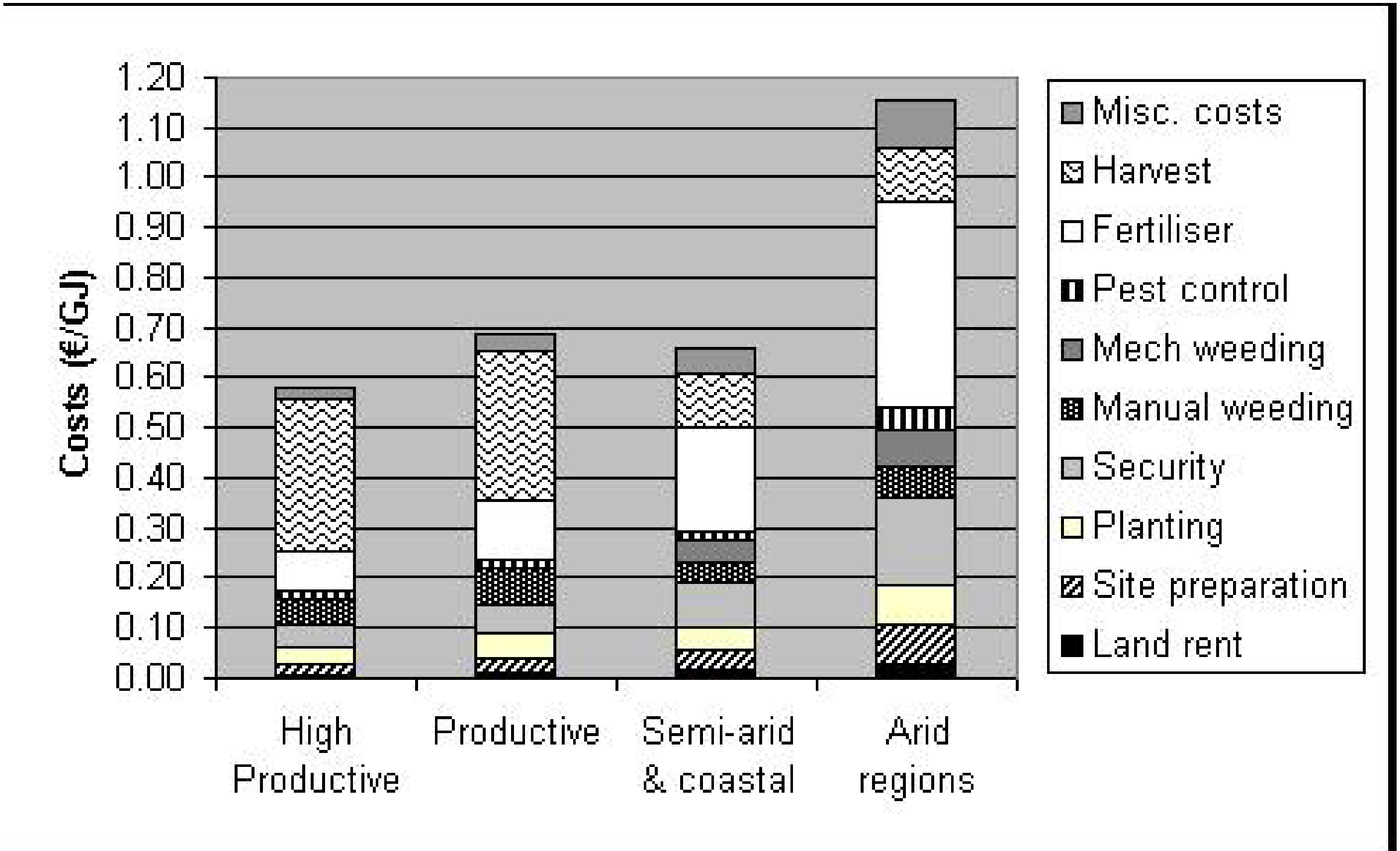
Comparison of bioenergy growing costs by region type (€/GJ)



[Batidzirai & Faaij, 2006]

Torrefaction…

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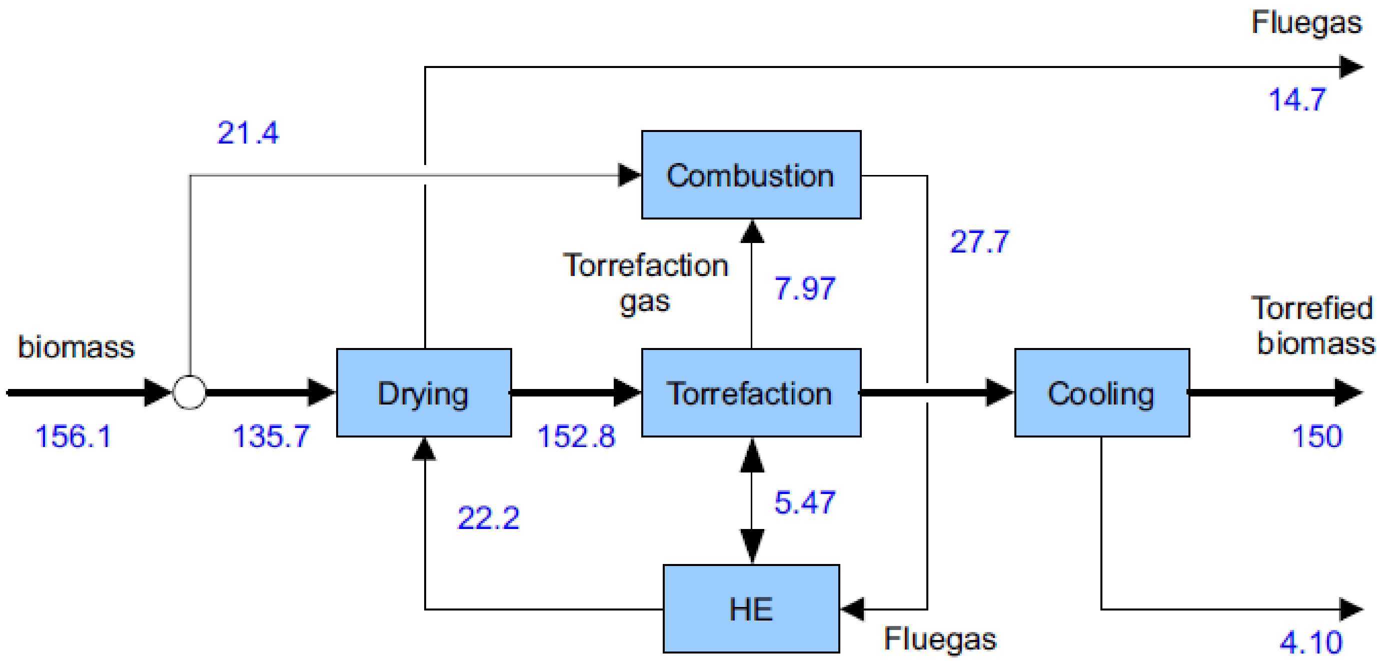
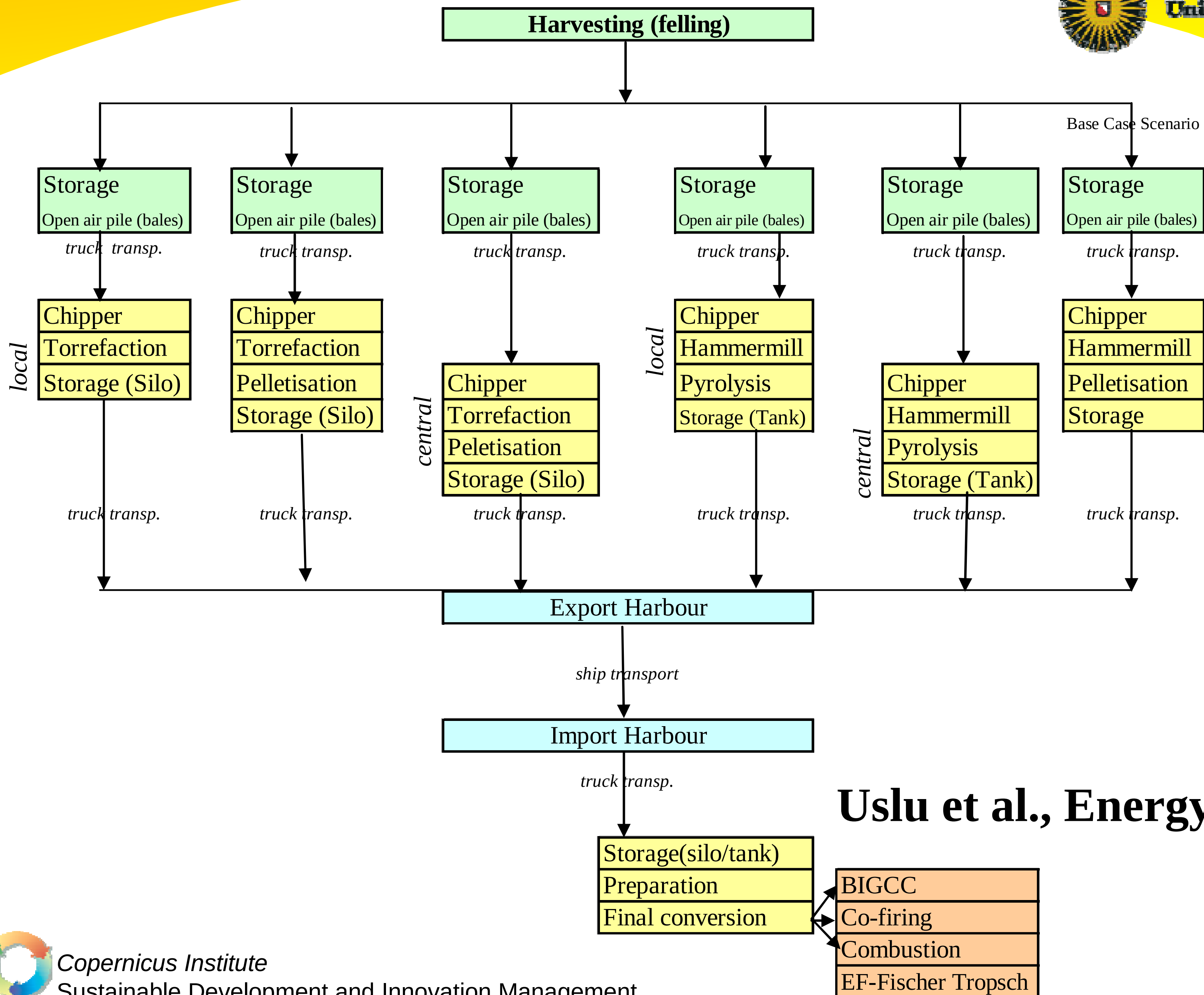


<u>From green wood chips</u>:

>90% energy efficient.

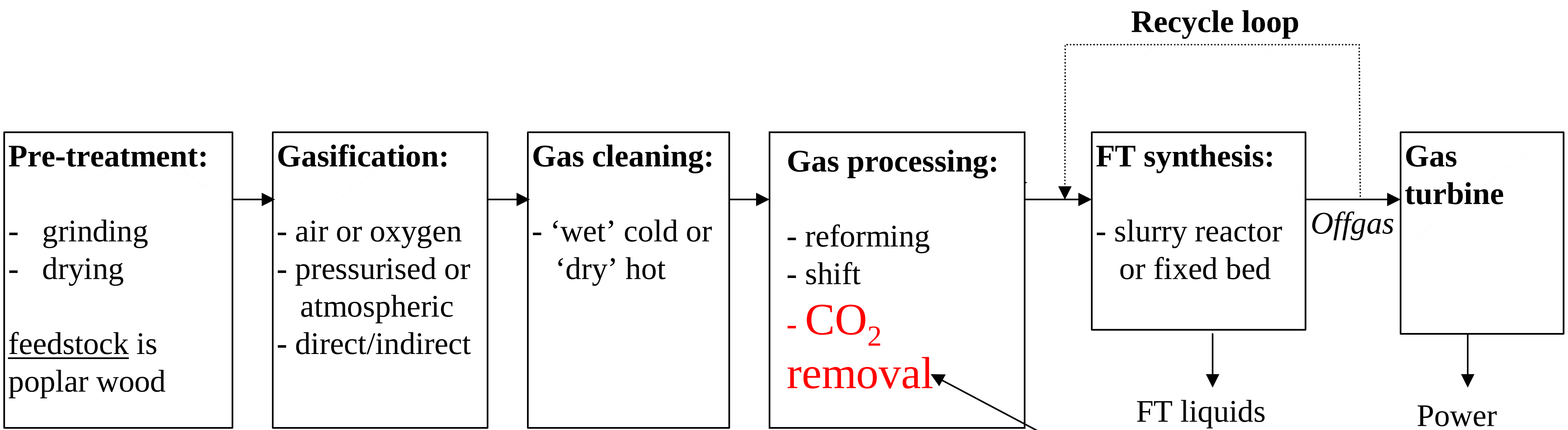
- Wood pellets: ~85%
- Pyrolysis ~70%

Uslu et al., Energy, 2008



Uslu et al., Energy, 2008

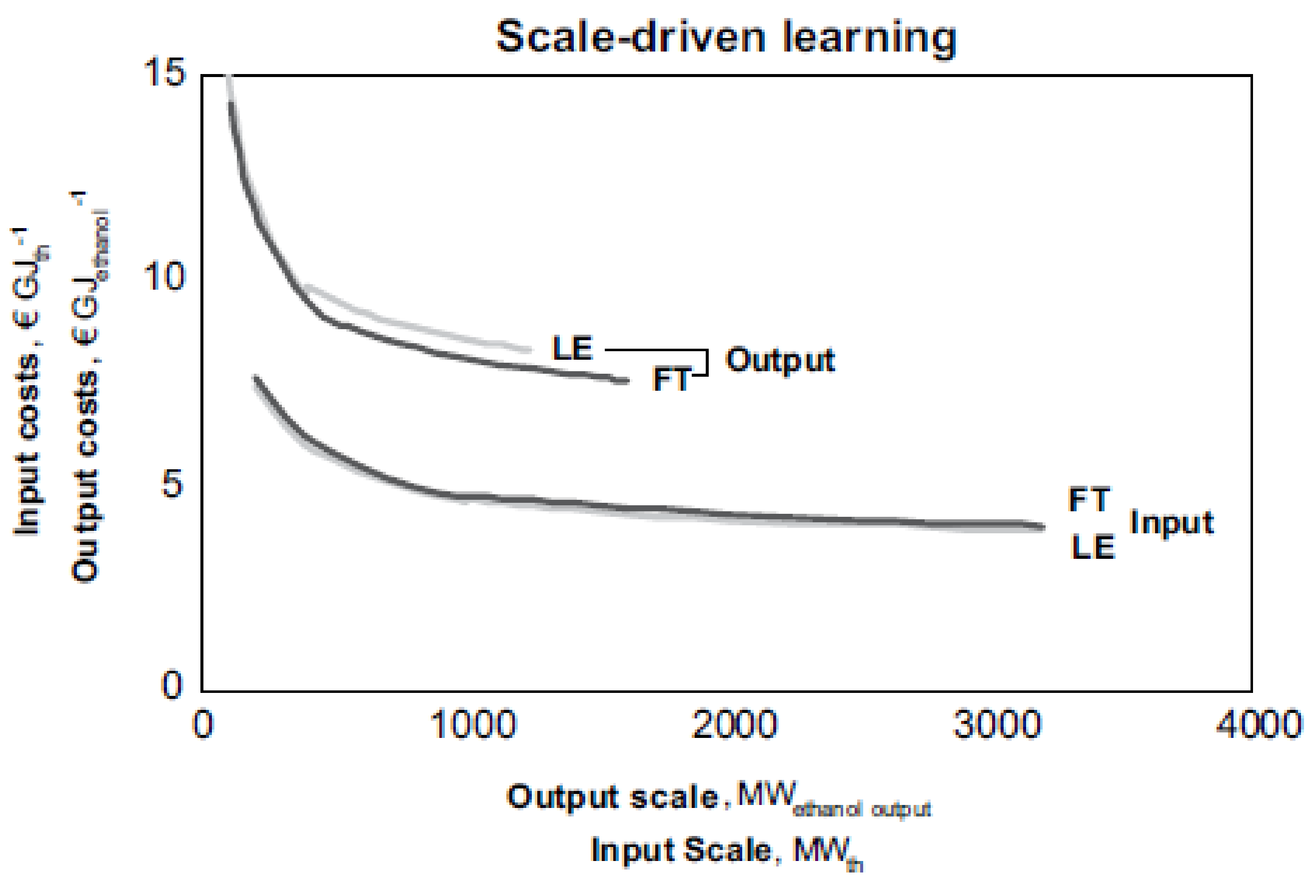
The ultimate energy transition machine: co-fed IG/synfuel/power +CCS



Major investments in IG-synfuel capacity ongoing in China **right now**:
- Reducing dependency on oil imports!
- 50 % biomass + CCS gives net 0 CO2 emissions.

About 50% of carbon!

Scale-driven learning curve for the lignocellulose to-ethanol (LE) and lignocellulose-to-Fischer–Tropsch (FT).



Wit et al., 2010, Biomass & Bioenergy

What are we waiting for?

Yueyang Sinopec-Shell Coal gasification project; (China)

Shell gasifier arriving at site September 2006.

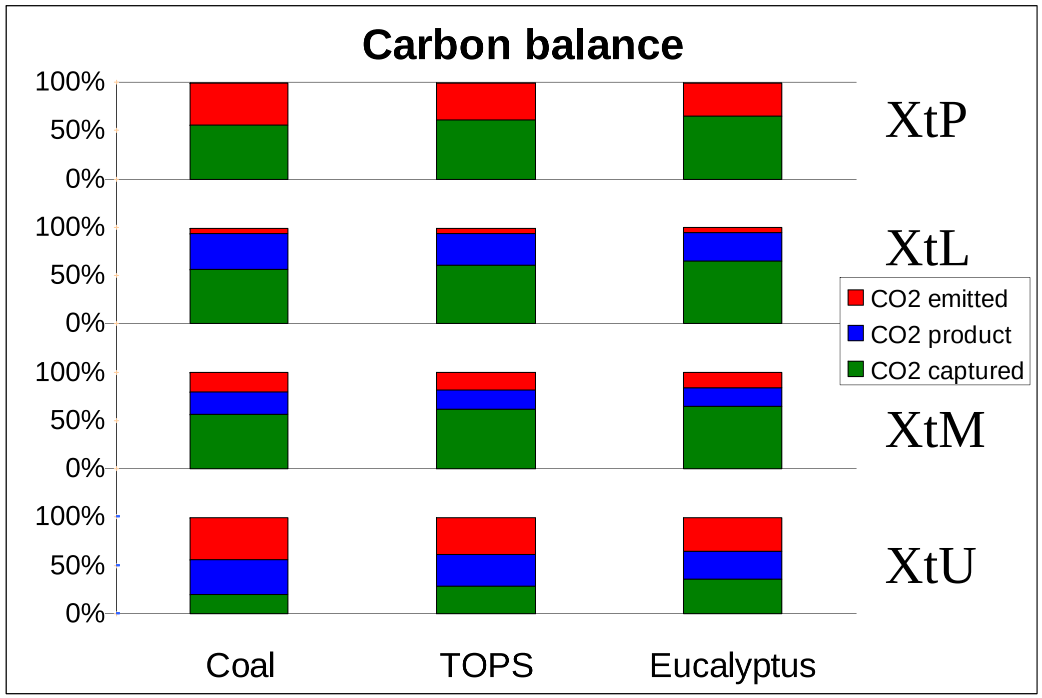
15 licences in China at present…

Courtesy of Shell

IG-PG performance

- Biomass has slightly lower efficiency
- TOPS performs better than raw wood

Eff	Coal	TOPS	Euca-lyptus
XtP	40%	40%	40%
XtL	62%	60%	57%
XtM	55%	54%	52%
XtU	57%	56%	53%



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Meerman et al., forthcoming

Main performance parameters (assumed biomass costs 1 – 1.8 Euro/GJ)

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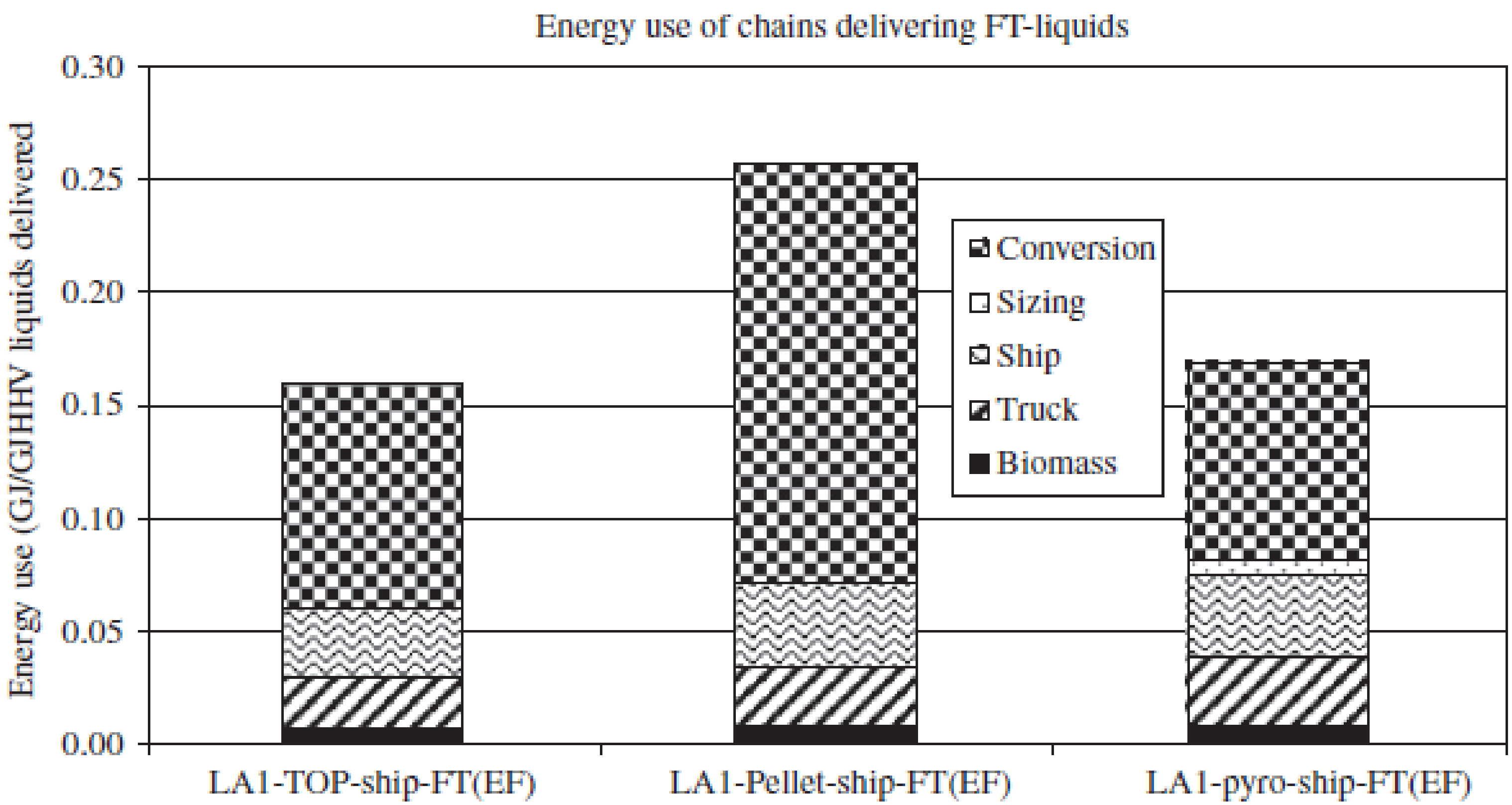
		TOP	*Pelletisation*	*Pyrolysis*
Process efficiency[1]	%	90.8	84-87	66-70
Product				
Energy content(LHV_{dry})	MJ/kg	20.4-22.7	17.7	17
Mass density	Kg/m^3	750-850	1200	500-650
Energy density	GJ/m^3	14.9-18.4	7.8-10.5	20-30
economics				
Specific capital investments	$M€/MW_{th}$	0.19	0.15	0.19-0.42
Production costs	€/ton	50	54	75-104

Uslu et al., Energy, 2008

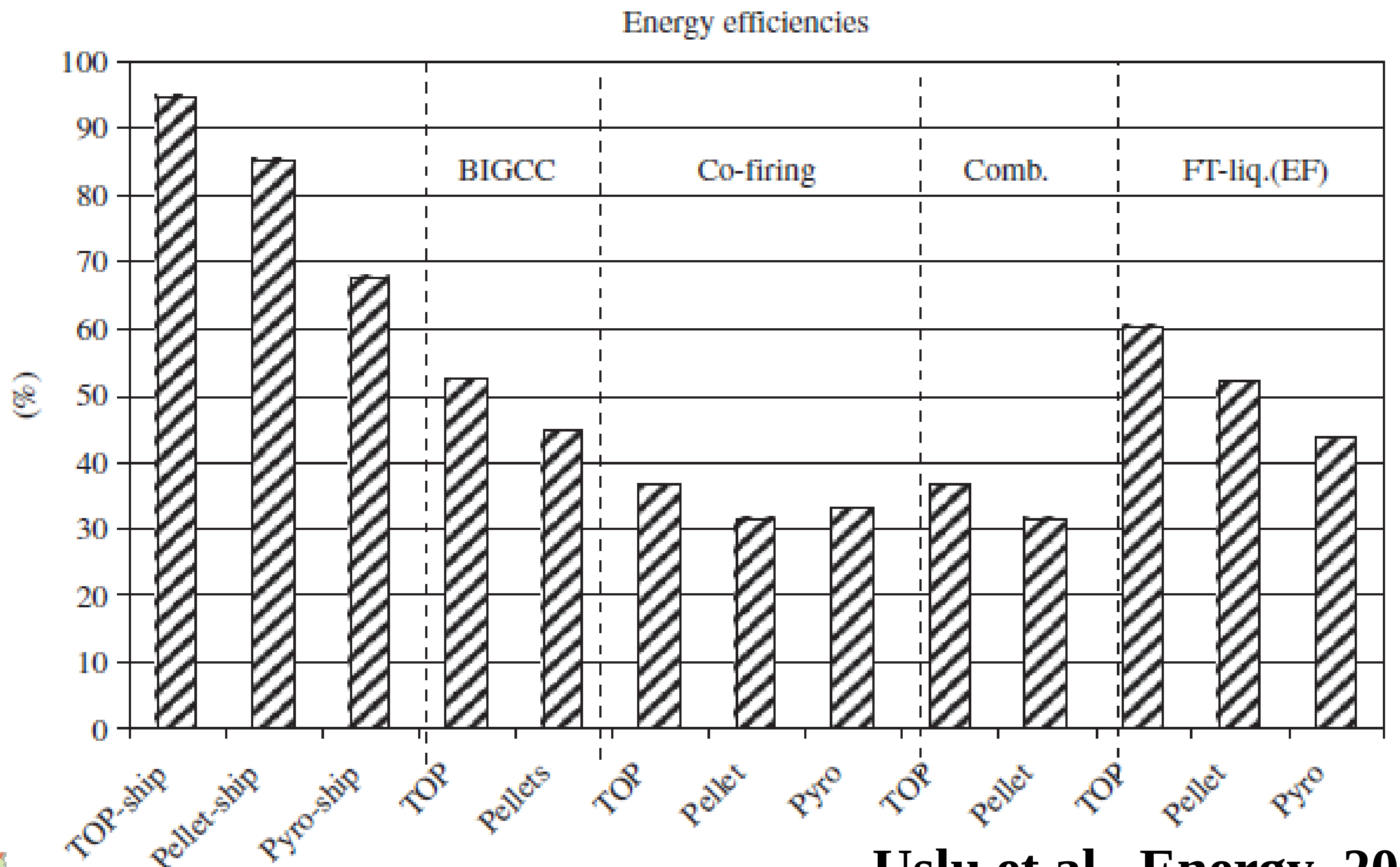
Energy use: GJ/GJ delivered



*Conversion includes pre-treatment + EF-FT

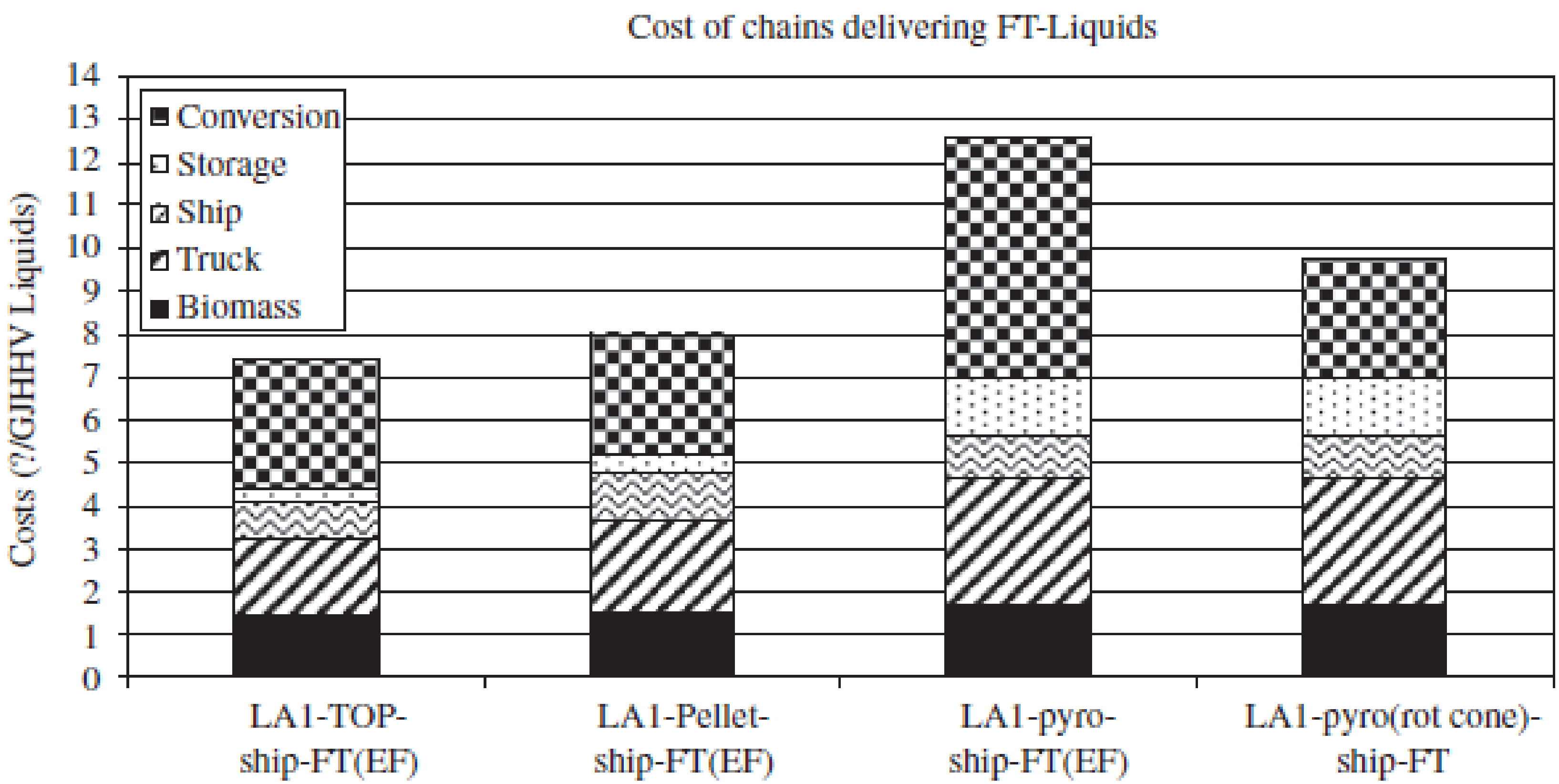
Uslu et al., Energy, 2008

Overall chain efficieny delivery of power and fuel



Uslu et al., Energy, 2008

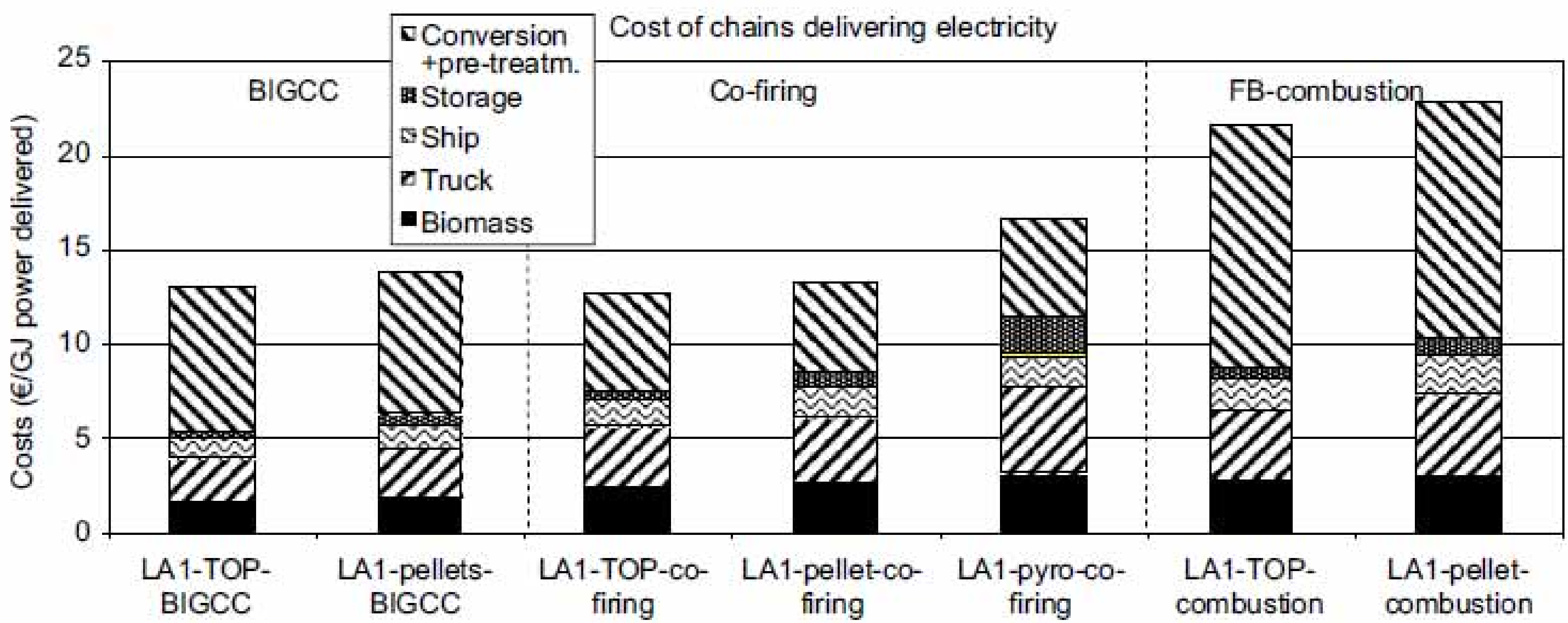
Economics FT (assuming fully developed technology and large scale volume)



*Conversion step includes both pre-treatment and final conversion

Uslu et al., Energy, 2008

Economics for power generation



Uslu et al., Energy, 2008

Final comparison (low biomass costs scenario)

	Intermediate delivered to harbour	*FT-Liquid fuel*	*Power (BIGCC)*	*Power (Co-firing)*
	€/GJ$_{HHV}$	€/GJ$_{HHV}$	€ct/kWh	€ct/kWh
TOP	3,3	6,4	4,6	4,6
Pellet	3,9	7,0	5,5	4,8
F.Pyrolysis	4,7 -6,5	9,5		5,9

Uslu et al., Energy, 2008

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Final remarks

- IF torrefaction delivers as projected it has significant positive impacts (E-balance, GHG, costs) on international trade chains and final conversion.
- Result presented project fully mature technologies and well developed markets; there are significant hurdles and expenditures in between.