

Availability of biomass and biomass supply systems for co-firing purposes

FUEL FLEXIBILITY IN BIOMASS COMBUSTION - THE KEY TO LOW BIO-ENERGY COSTS? Workshop organised by International Energy Agency (IEA) Bioenergy Task 32: Biomass Combustion and Co-firing, Jönköping, 31.5.2006

Martin Junginger & André Faaij

Copernicus Institute - Utrecht University





Overview

- 1. Current developments of biomass cofiring in the Netherlands.
- Future supply chains resources and pretreatment technologies (for biomass co-firing)
- 3. Some work of IEA bioenergy Task 40

Domestic renewable electricity production in the Netherlands

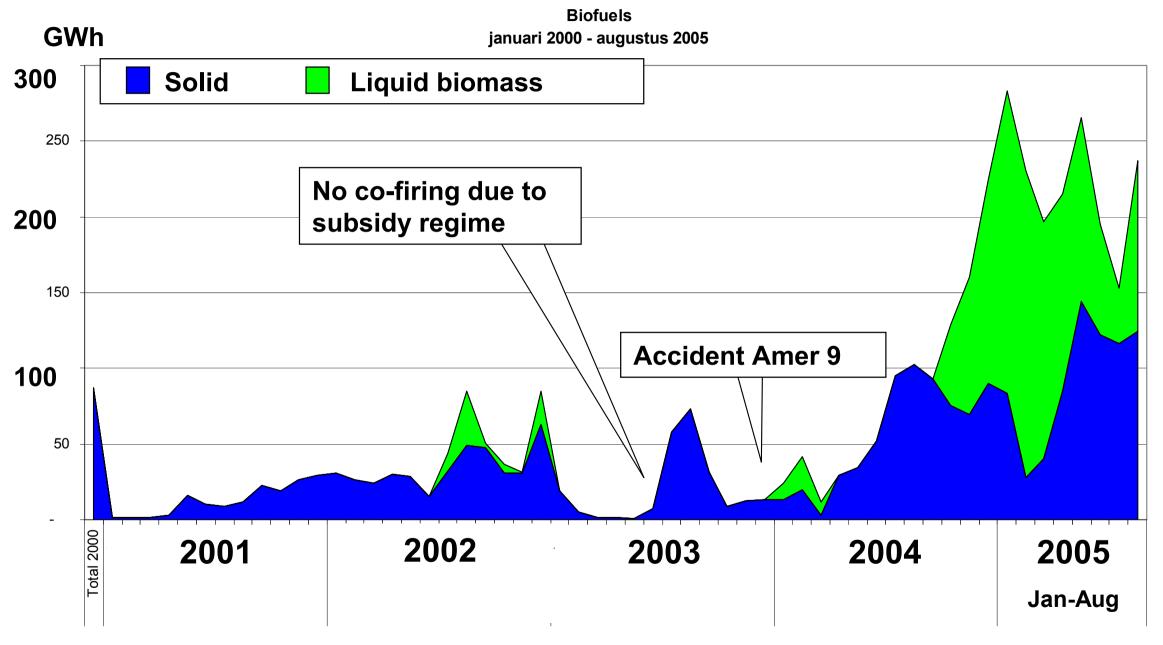


Annual domestic renewable electricity production (TWh) 8 Biomass digestion & other 6.2% Biomass cofiring 7 MSW organic waste fraction From <1% in 6 □ PV 1995 to almost Wind onshore 4.3% 50% of 5 Small hydro renewable electricity 4 production in Percentage of total national 3.3% 3.3% electricity consumption: 2005 2.7% 3 2.6% 2.2% 2.1% 2 1.7% 1.8% <u>1.0%</u>1.1% 1.1% 1.2% <u>1</u>.3% 0.9% 0.8% 0 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005

Co-firing of solid and liquid biomass in Essent power plants



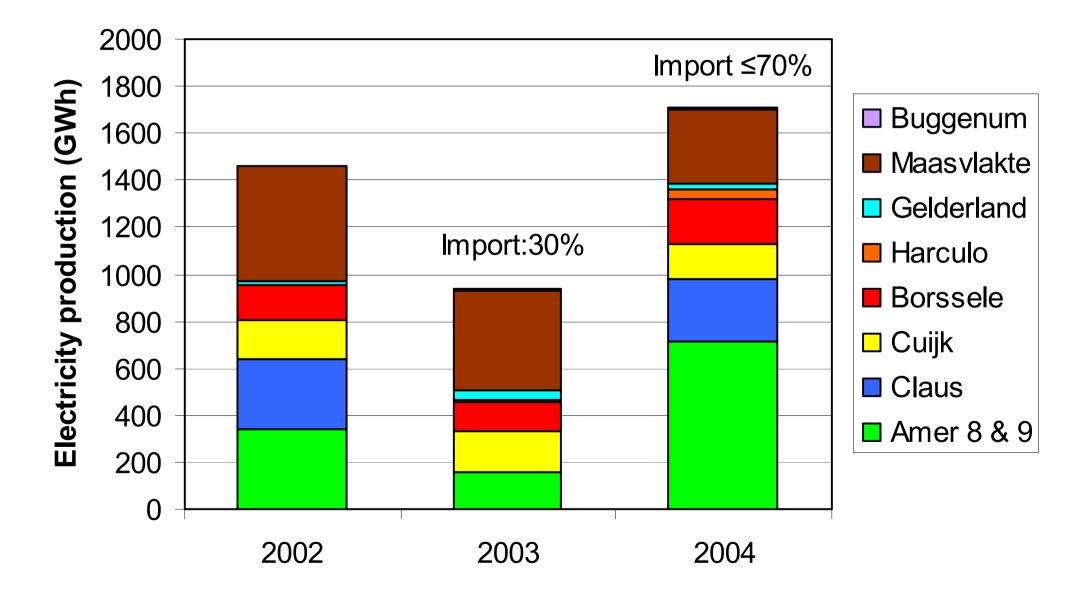
Universiteit Utrecht



Source: P.P. Schouwenberg, Essent Sustainable Energy



Electricity production from biomass co-firing in power plants





Imported fuels used:

- Wood pellets (mainly from Canada)
- Agro-residues (palm kernel shells, olive nuts, nut shells, cocoa husks, soy and sun flower residues)
- Palm Oil (Malaysia and Indonesia)
- Bone Meal and other waste streams



Current (policy) trends

- Palm oil deemed unsustainable, feed-in tariff cut from 7 €ct/kWh to <3 €ct/kWh
- Pellet market very volatile, present shortage of pellets
- Development of sustainability criteria for biomass, likely including CO2/energy balance, food security and nature& biodiversity criteria
- => New efficient & sustainable biomass supply chains needed



A

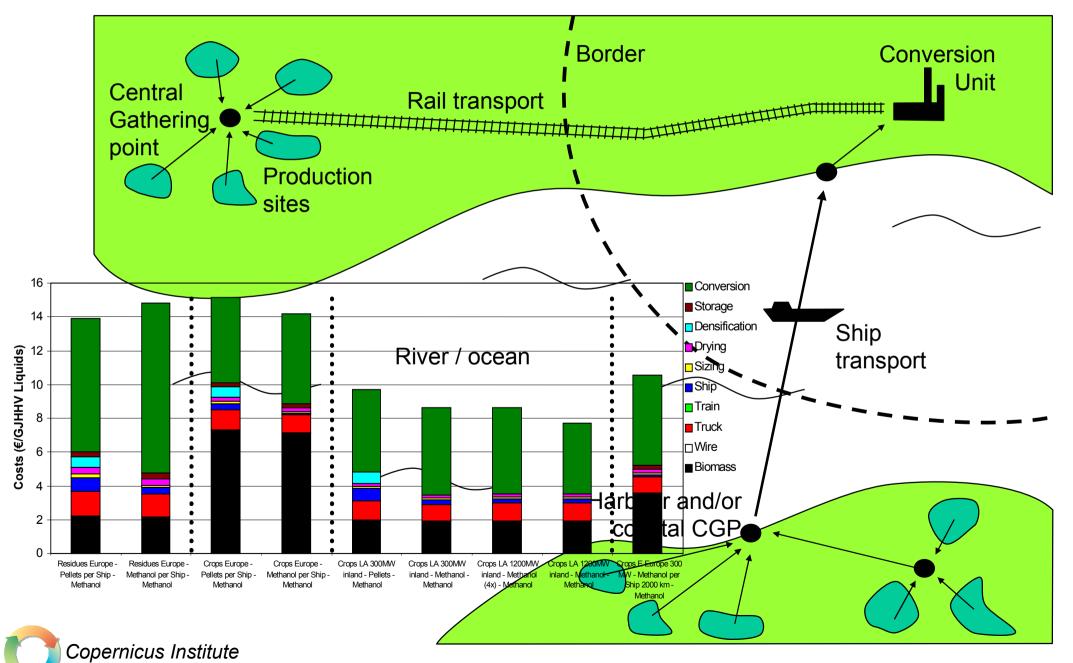
Agricultural land: <100->300 EJ Marginal lands: <60-150 EJ Agri residues: 15-70 EJ 111 136 Forest residues: <30-150 EJ 178 CIS & W Enron **Dung: 5-55 EJ** Baltic States **Organic waste: 5 - >50 EJ** Europe Japan Near East & East Asia 315 North America North Africa 331 **TOTAL:** < 250 - > 500 EJ 178 South Asia Caribean & Oceania harvesting residues Latin America sub-Saharan ■ bioenergy crops Copernicus Institute Africa

Sustainable Development and Innovation Management

candoned cropland w-productive Land

International bio-energy logistics **not a showstopper** *when organized rightly*

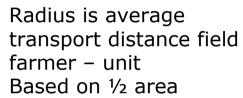
Universiteit Utrecht



Sustainable Development and Innovation Management

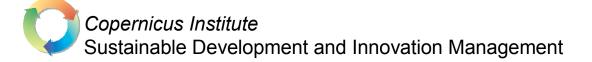


Logistic concept for production regions



Field farmers are spread in area

Required area in km2: Based on: 1Field coverage 2Biomass distribution density Unit X requires certain biomass input "A"





Many possible 'biotrade chains'

Exporter	Transport/transfer/sto rage	Importer
Biomass production	'raw' biomass	Full conversion
Biomass production & pre-treatment	Pre-treated (pellets, bales, bio-oil) biomass	(partial) conversion
Biomass production & conversion	Fuels (H2, MeOH, EtOH, HC's)	End-use
Production and conversion	Electricity transport	End-use
Biomass production	'conversion along the way'	End-use



Composing chains...

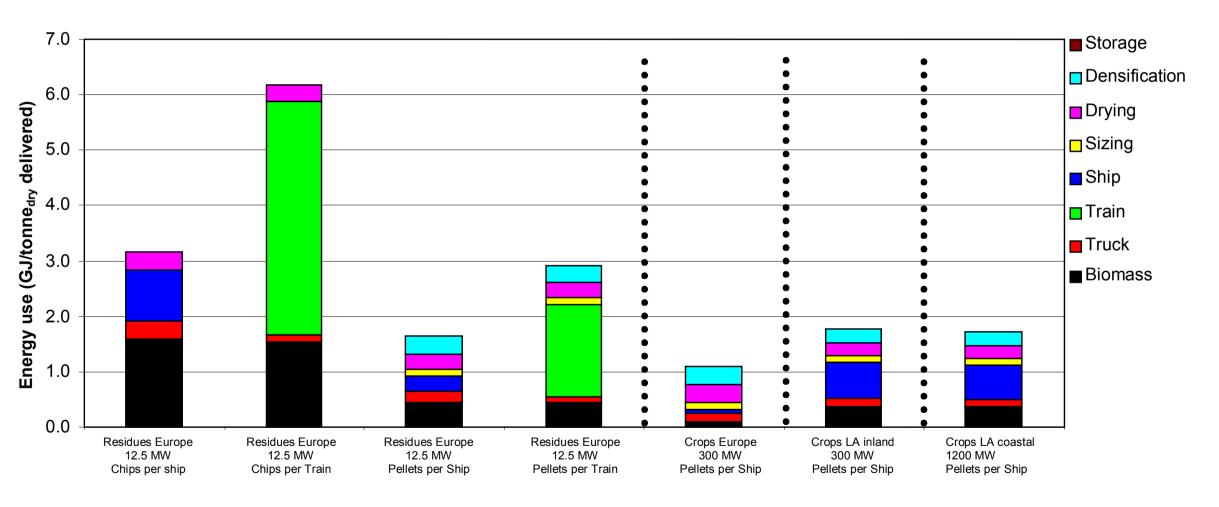
Logs	ogs Chips Bales		I	Bales Pellets Logs ^{>} Briquettes		Bales Logs > MeOH		Bales Logs > Pyro			
Roadside	Roadside	© ⊫) 00 mm	© ⊫)°°° 30 8°°8 mm	Å₽©	Å∰⇔©		$(\mathscr{W} \bowtie)$	$(\mathscr{W} \bowtie \odot)$	$(\mathscr{W} \square \bigcirc)$		
Dedicated 50 km	Dedicated 50 km	Roadside	Roadside	Roadside		0000		0000		Roadside	Roadside
CGP 100 km	CGP= Terminal 1100 km	Dedicated 50 km	Dedicated 50 km	Dedicated 50 km	Dedicated 50 km	Dedicated 50 km	Dedicated 50 km	Dedicated 50 km	Dedicated 50 km	© ⊫,° 30 ∞ mm	©⊟,°° 30 ,°° 8 mm
		SSS CGP	≷≹≹ CGP= °°°∞° Terminal	CGP	CGP= Terminal	CGP	CGP= Terminal	CGP	CGP= Terminal	°°°°°	
Harbour 1 <u>100 - 11,500</u> km	Plant	×200		100 km	1100 km	© ⊫) ₀₀₈ 30 mm	© , 30 ∂°°8 mm	©⊟,°°° 30 8°°8 mm	© , 30 ♂°° 8 mm	‰s⇔∲ <u>150</u> km	\$\$°8 50 km
100 km	© ➡,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	100 km	1100 km	Harbour	Plant						
	~~~~ ~~~~	Harbour	Plant	1100 - 11,500 km	© ➡;°° 30 &°°8 mm		(°°°8 <b>⇔</b> 10 mm)	å:⇔	ॐ₃₽♠	Harbour 1100 - 11,500 km	Terminal
SSS Plant SDD SSS Plant SSS 30 mm	°°, ₽`(₽`/₪	1100 - 11,500 km		100 km	**** ****			100 km	<u>1100 km</u>		
Market Ma		100 km	<i>8</i> 38 <b>- ○</b> / <b>●</b>		°; <b>⊨</b> €/M	100 km	1100 km		<u> </u>	100 km	Plant
;;, <b>⇒</b> €/&								Harbour	Plant	Plant	∮⇒€∕M
		Plant		© , 30 % 8 mm ≥>>		Harbour 1100 - 11,500 km	^م ر Plant	1100 - 11,500 km		∲¤©∕M	
		°°°,≓)€∕⊗					∾≓€∕&	100 km			
				%;8 <b>⁻ ' └ / ₪</b>		100 km		Plant			
						Plant					

Legend

	Harvest or collection	豢	Loose biomass		Storage of logs or bales	⇒	Conversion
	Transport per truck (solids)	$\odot$	Logs or bales	<u> Z</u> ®	of chips or fines	E	Electricity
	per train	60 0 60 0 00	Chips 30 mm		in a silo	Þ	Pyrolysis oil
	per ship	2.63 23 -	Fines 10 mm		of liquids (in tank)	M	Methanol
Copel Susta	of liquids		Pellets or briquettes	89999 89999	Drying chips		



## Primary energy use of biomass supply chains to a Dutch power plant

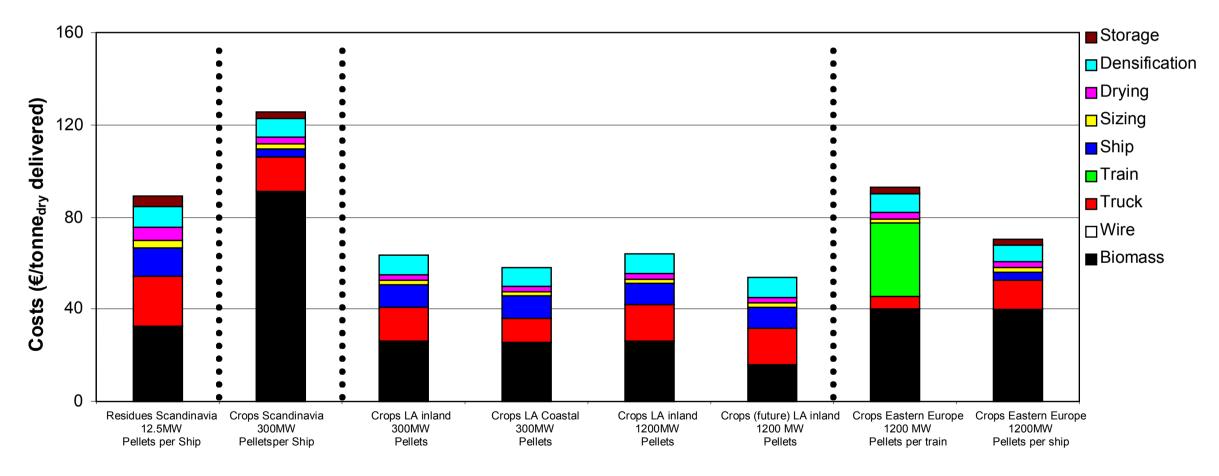


*Copernicus Institute* Sustainable Development and Innovation Management

#### Source: Hamelinck, Faaij, 2003



# Cost breakdown of solid biomass delivered to the Netherlands

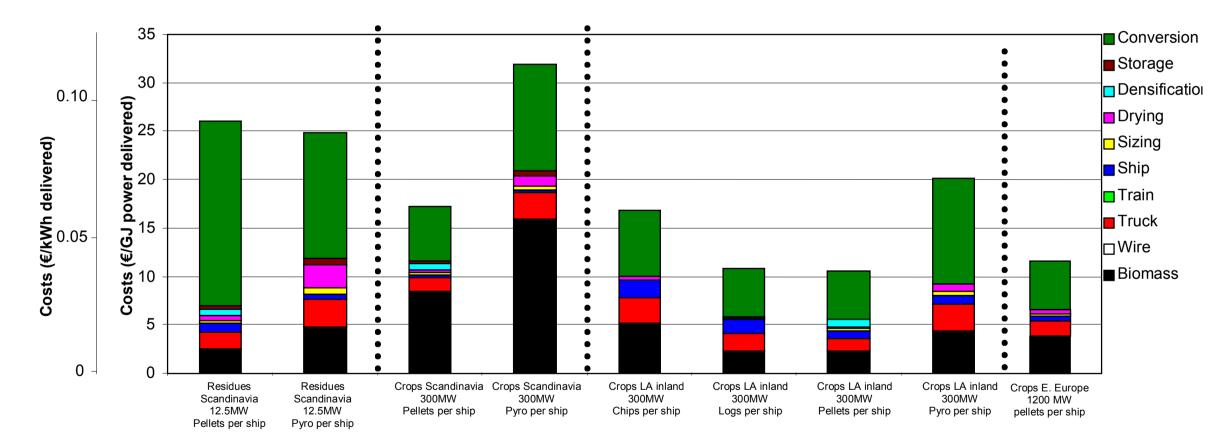


Copernicus Institute Sustainable Development and Innovation Management

#### Source: Hamelinck, Faaij, 2003



# Cost breakdown of electricity delivered to the Dutch grid



*Copernicus Institute* Sustainable Development and Innovation Management Source: Hamelinck, Faaij, 2003

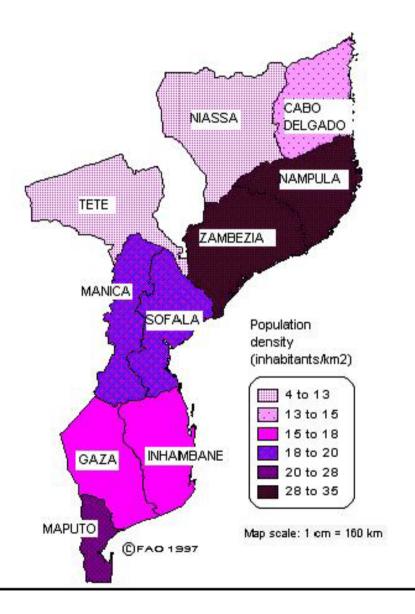


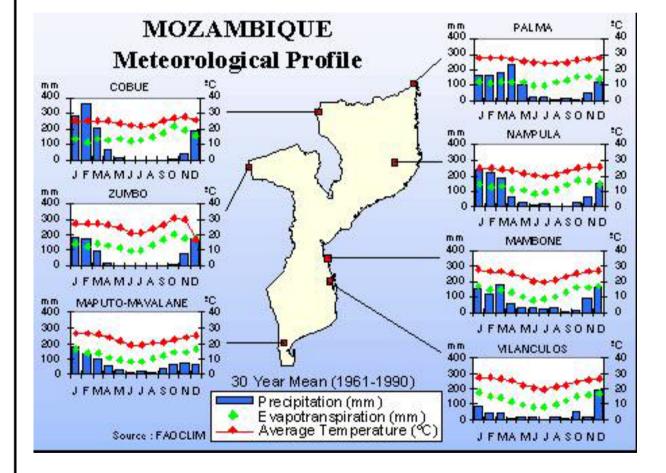
### Some key findings...

- Reference systems importing & exporting country crucial for net GHG impact.
- Economies of scale are 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.).



### Mozambique...





Batidzirai & Faaij, 2005



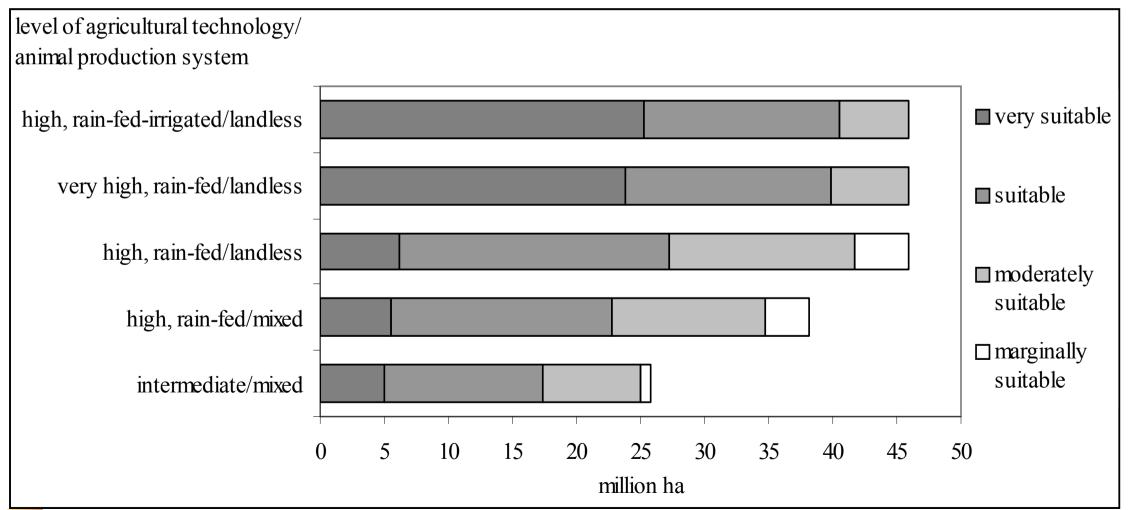
#### Level of advancement of agricultural technology

Level of agricultural technology	Water supply	Description
Low	rain-fed	No use of fertilizers, pesticides or improved seeds or breeds, specialised health care for animals and calf rearing activities, equivalent to subsistence farming as in rural parts of e.g. Africa and
Intermediate	rain-fed	Asia. Some use of fertilizers, pesticides, improved seeds or breeds, animal health care and mechanical tools.
High	rain-fed	Full use of all required inputs and management practices as in advanced commercial farming presently found in the USA and EU.
Very high	rain-fed	Use of a high level of technology on very suitable and suitable soils, medium level of technology on moderately suitable areas and low level on moderately and marginally suitable areas.
Very high	rain-fed/ irrigated	Same as a very high input system, but including the impact on irrigation on yields and areas suitable for crop production.



### Potential surplus agricultural land in 2015 in Mozambique, dependent on the level of

### advancement of agricultural technology



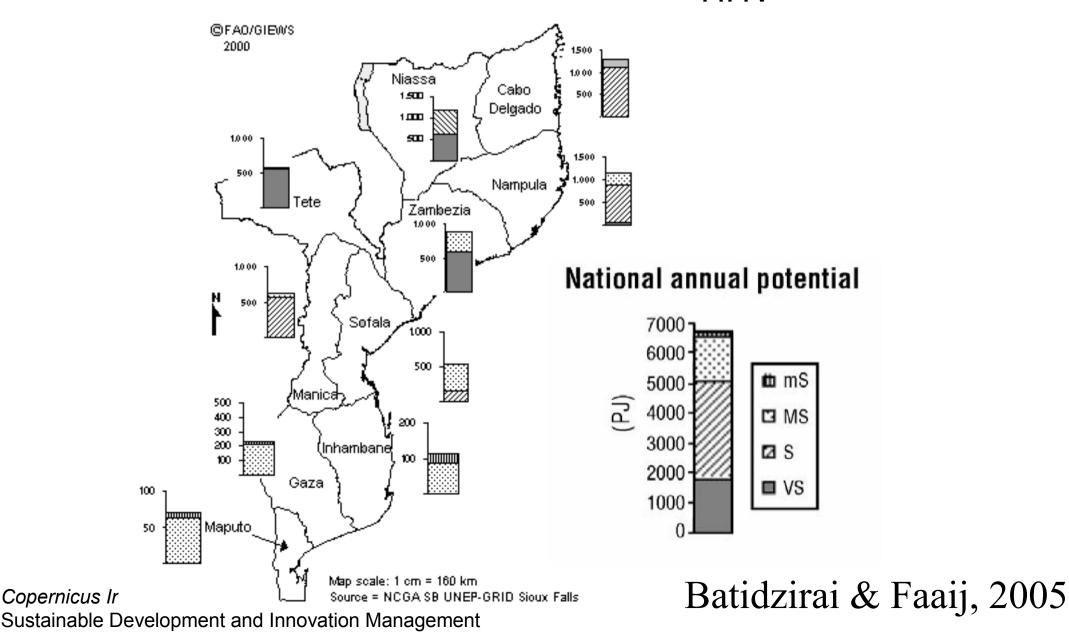
Copernicus Institute

Sustainable Development and Innovation Management

Batidzirai & Faaij, 2005

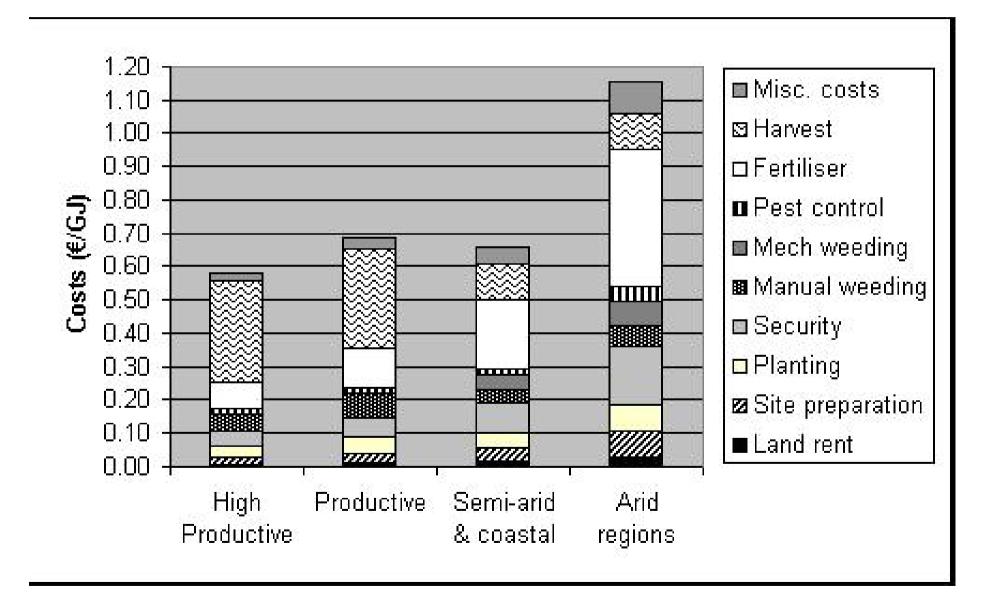


# Regional biomass annual production potential in Mozambique/PJ_{HHV} (2015)

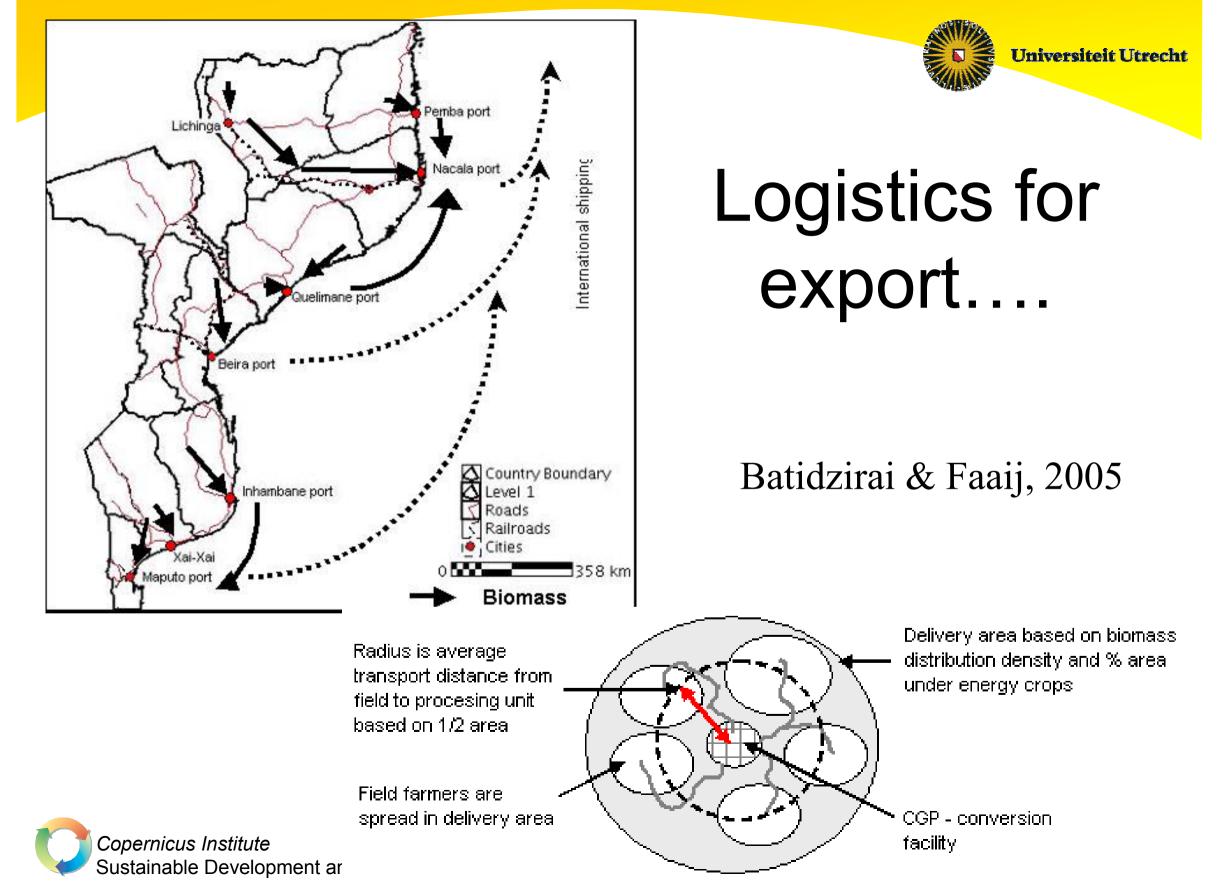




### Comparison of bioenergy growing costs by region type (€/GJ)

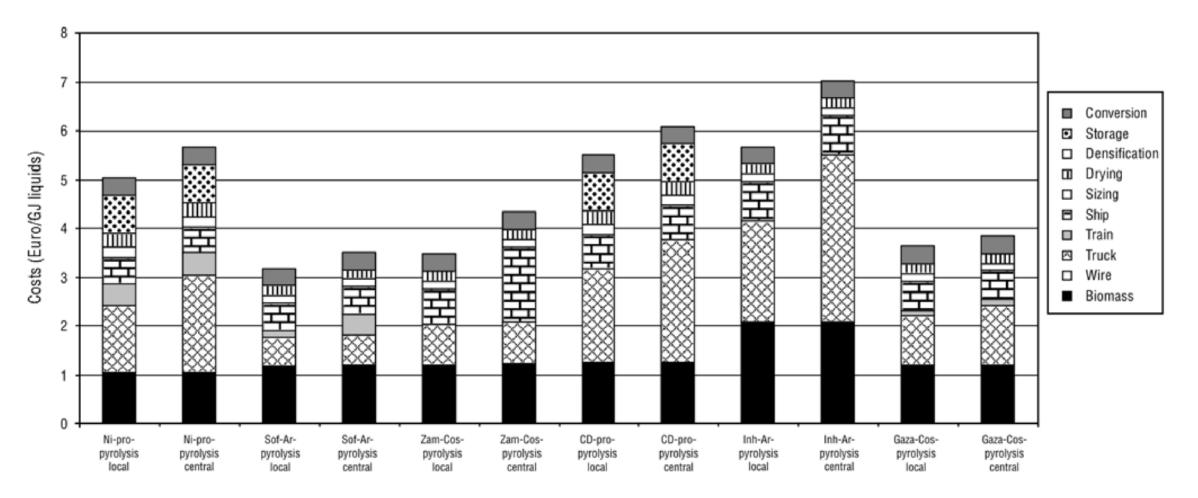


*Copernicus Institute* Sustainable Development and Innovation Management Batidzirai & Faaij, 2005





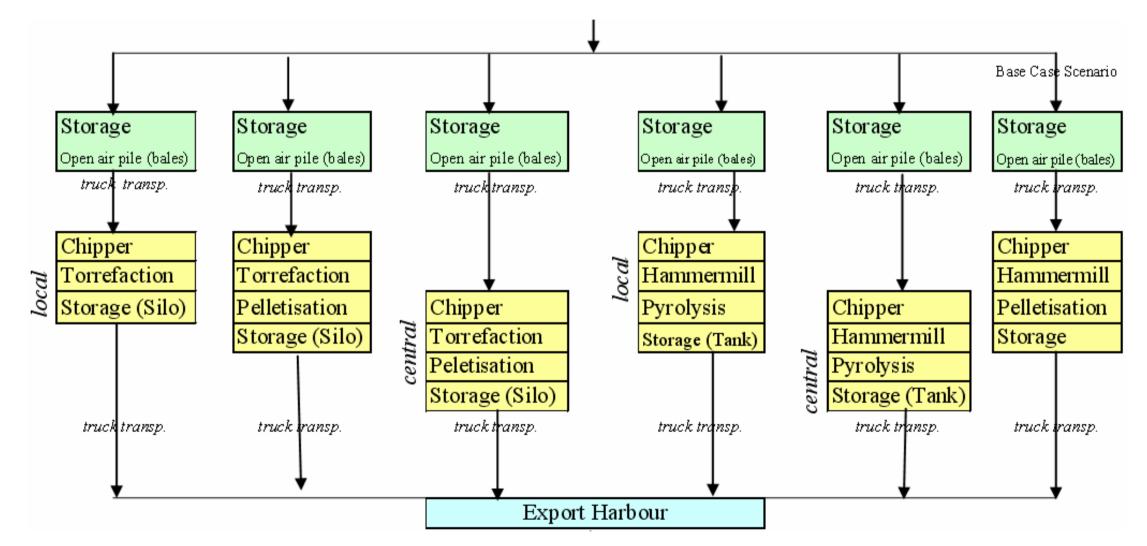
# Chains supplying pyrolysis oil from Mozambique to Rotterdam

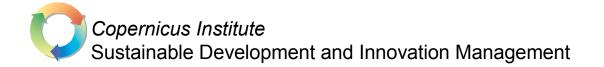


Copernicus Institute Sustainable Development and Innovation Management Batidzirai & Faaij, 2005



### Comparison of Torrefaction, pellets and Pyrolysis pretreatment



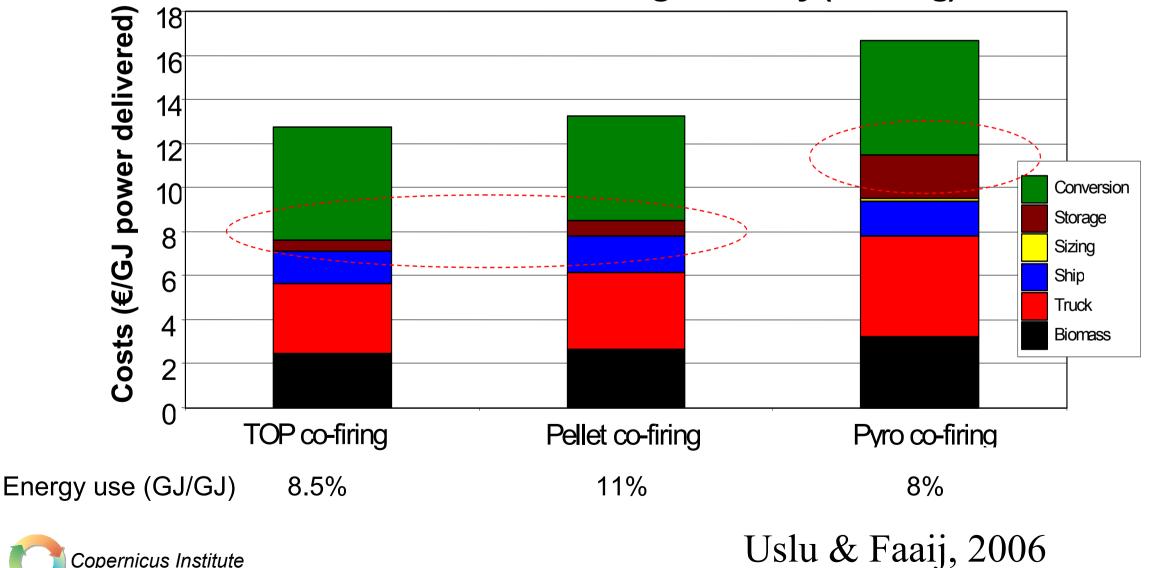


Uslu & Faaij, 2006



## Comparison of co-firing wood pellets, torrefied pellets (TOP) and Pyrolysis oil

Cost of chains delivering electricity (co-firing)



Sustainable Development and Innovation Management

### Relevant work of IEA bioenergy Task 40

Country reports

- on Brasil, Finland, the Netherlands, Norway...
- Updated country reports and synthesis report to be published in autumn 2006

Market studies:

- on ethanol (published)
- on global wood pellet markets and resources (to be published end of 2006)
- On pyrolysis oil (to be published end of 2006)
- => Keep an eye on www.bioenergytrade.org



### Thank you for your attention!

Refs to the studies presented:

Carlo Hamelinck, (C.N.), Outlook for advanced biofuels, Ph.D. thesis, University of Utrecht, 2004, 232 pp. (NWS-E-2004-25)

Batidzirai, Faaij and Smeets, Biomass and bioenergy supply from Mozambique, Energy for Sustainable Development, Volume X (1), March 2006.

Faaij and Uslu, Pretreatment technologies and their effects on international bioenergy supply chain logistics, Techno-economic evaluation of torrefaction, fast pyrolysis and pelletisation. Forthcoming.

Available at <a href="http://www.chem.uu.nl/nws">www.chem.uu.nl/nws</a> -> publications