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The Biomass option: developing markets and international trade.

- YES-DC Lecture Series

Utrecht, June 29, 2005 -

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Copernicus Instituut – Universiteit Utrecht

Copernicus Institute
Sustainable Development and Innovation Management

Elements:

- Context.
- Global resource potentials
- Developing international trade.
- Sustainability
- (Technological options and development pathways)

Bio-energy use worldwide

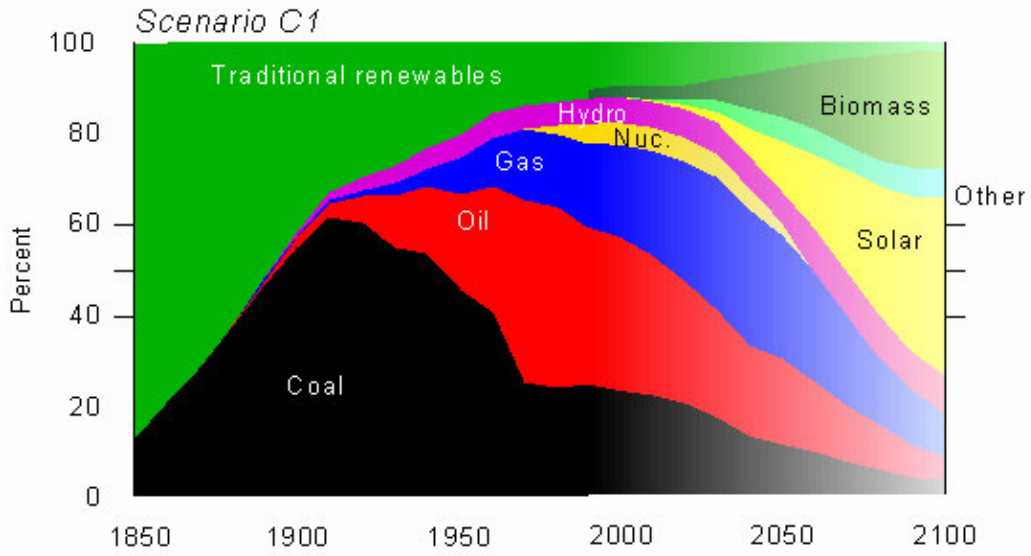
- Global Energy Demand: ~420 EJ
- About 10-15% (or 45 $\pm$ 10 EJ) of this demand is covered by biomass resources.
  - Traditional biomass: ~29
  - Commercial non-modern: 9 $\pm$ 6 EJ
  - Commercial: ~7 EJ
  - Liquid Biofuels ~0.5 EJ

Commercial bioenergy production worldwide (2001, WEA)

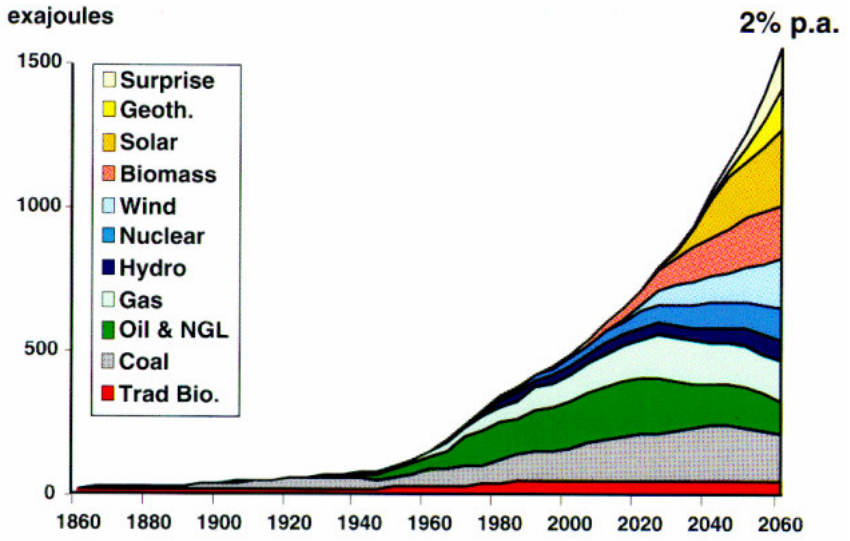
echnology	Increase in energy production 1997-2001 *(%/year)*	Operating capacity, end 2001	Capacit y factor *(%)*	Energy production, 2001	investment costs *(US$/kW*
Electricity	~ 2.5	~ 40 GWe	25 - 80	~ 170 TWh (e)	500 - 6,000
Heat [a]	~ 2	~ 210 GWth	25 - 80	~ 730 TWh (th)	170 - 1,000
Ethanol	~ 2	~ 19 bln litres		~ 450 PJ	
Bio-diesel	~ 1	~ 1.2 bln litres		~ 45 PJ	

a: Heat embodied in steam (or hot water in district heating), often produced by combined heat and power systems using forest residues, black liquor, or bagasse.

Future world's energy supply… (combined with 80% reduction of GHG-emissions)



Courtesy of IIASA



Courtesy of Shell

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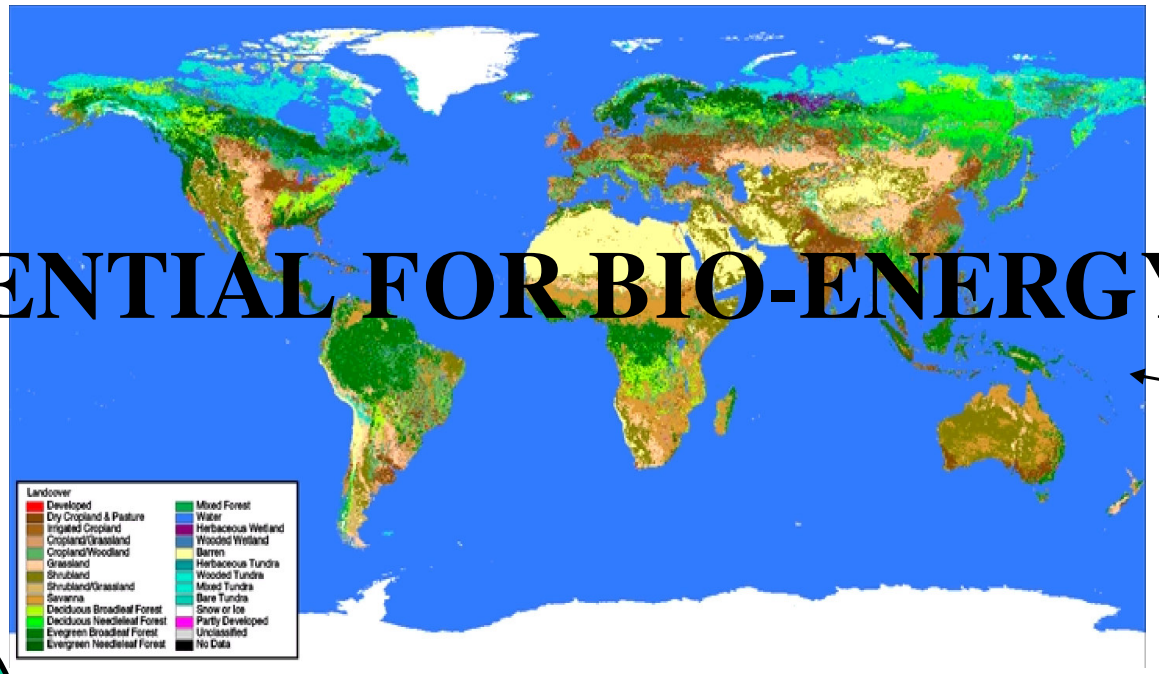
population

energy consumption

trade

future land use patterns

biotechnology



POTENTIAL FOR BIO-ENERGY?

GDP

agricultural system irrigation, breeding, mechanization, chemicals

land productivity

agricultural policy

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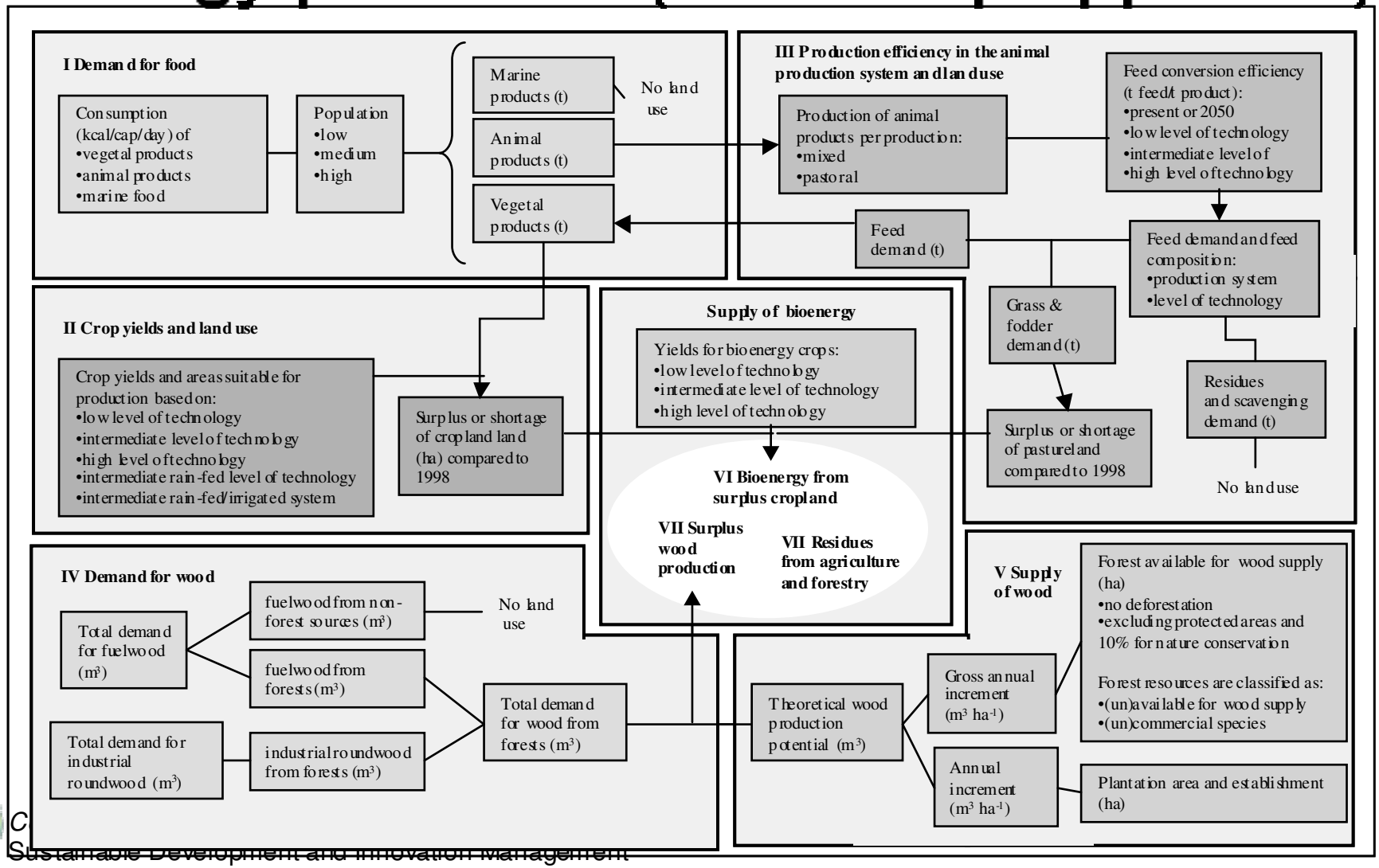
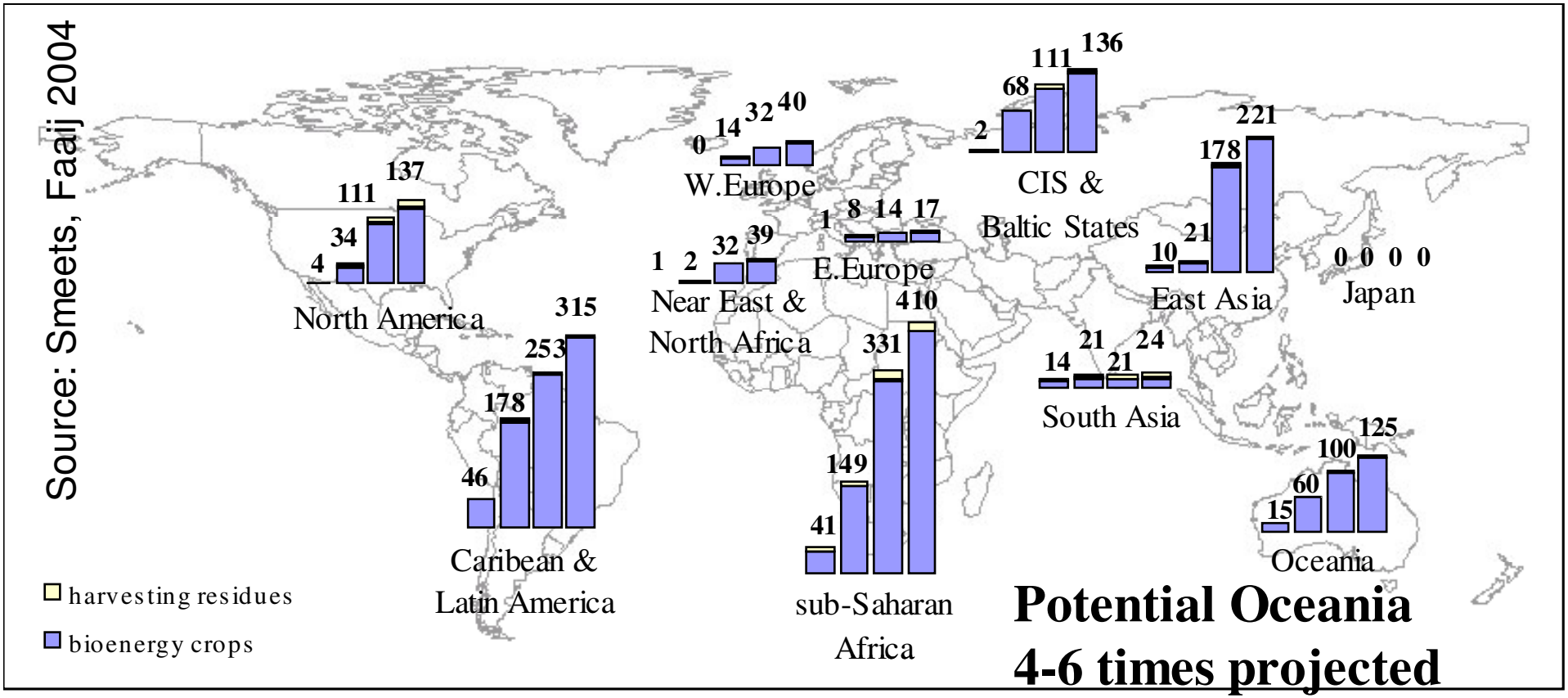
Key elements for assessing future bioenergy potentials (bottom-up approach)



Source: Smeets, Faaij 2004

Bioenergy production potential in 2050 for different scenario's



Potential Oceania 4-6 times projected primary energy use

B1-2010

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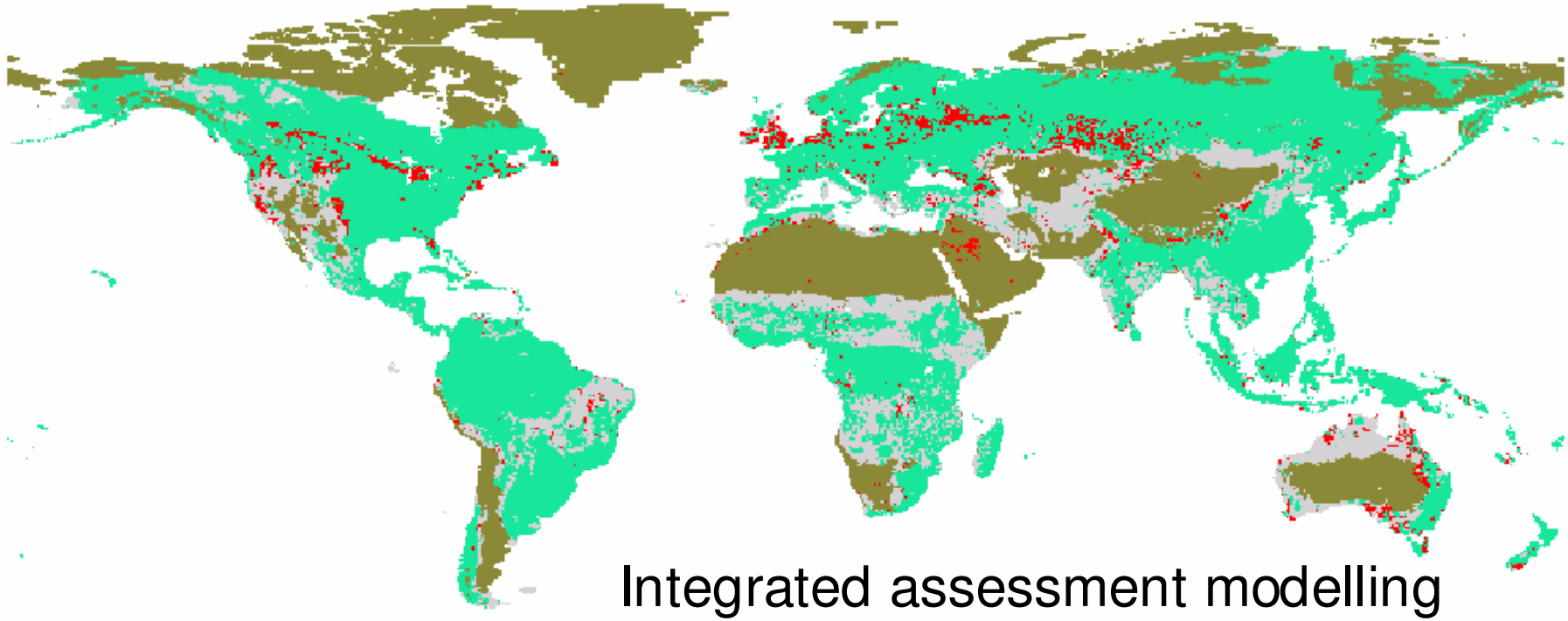

Source: Hoogwijk, Faaij 2004

rest land
Abandoned cropland
low-productive Land
Other

Integrated assessment modelling using IMAGE (RIVM) for assessing land-use and production potentials of biomass for energy

B1 2020

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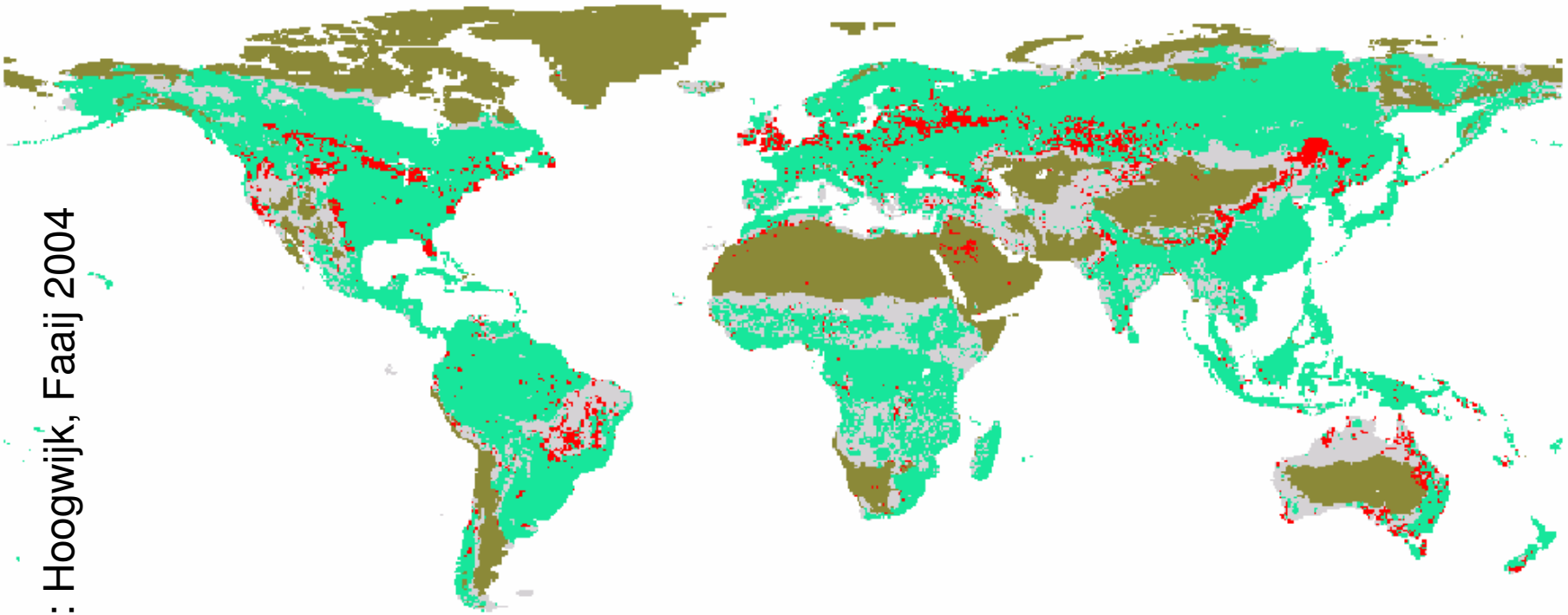

Source: Hoogwijk, Faaij 2004

- rest land
- Abandoned cropland
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B1 2030

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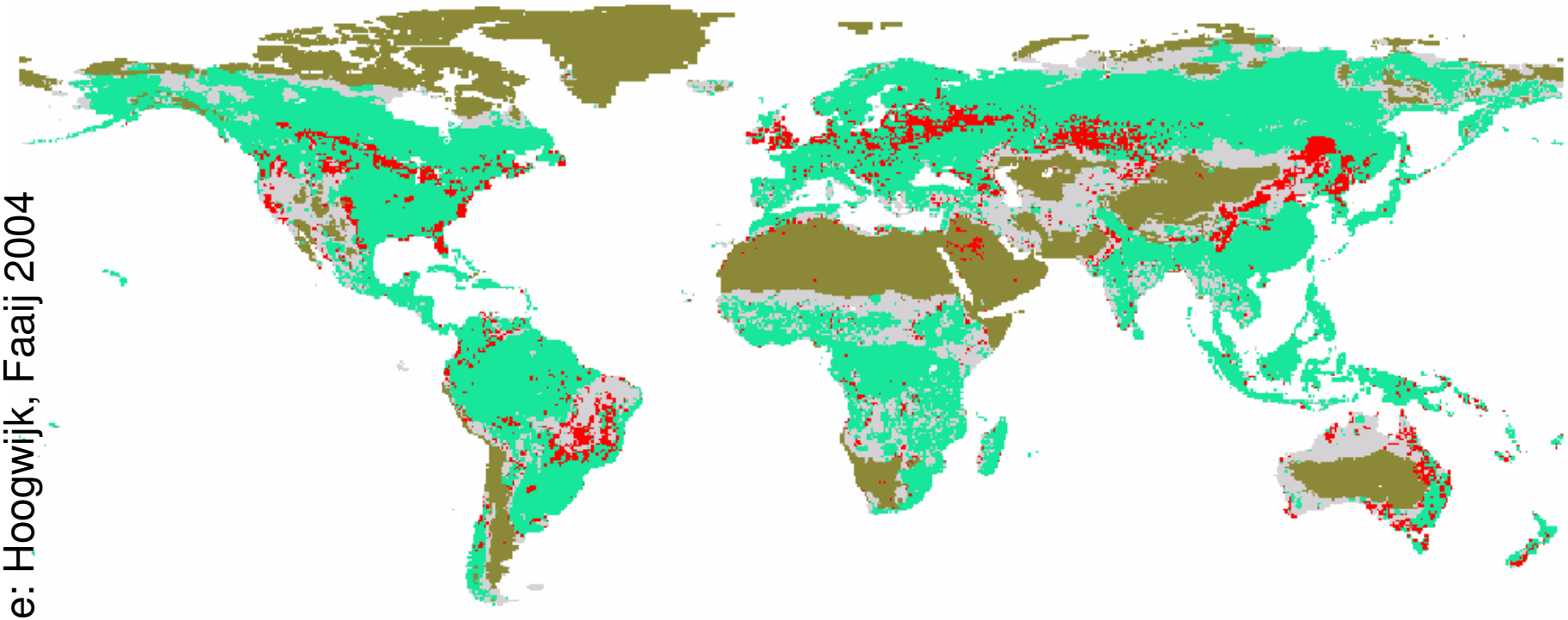

Source: Hoogwijk, Faaij 2004

rest land
Abandoned cropland
low-productive Land
Other

B1 2040

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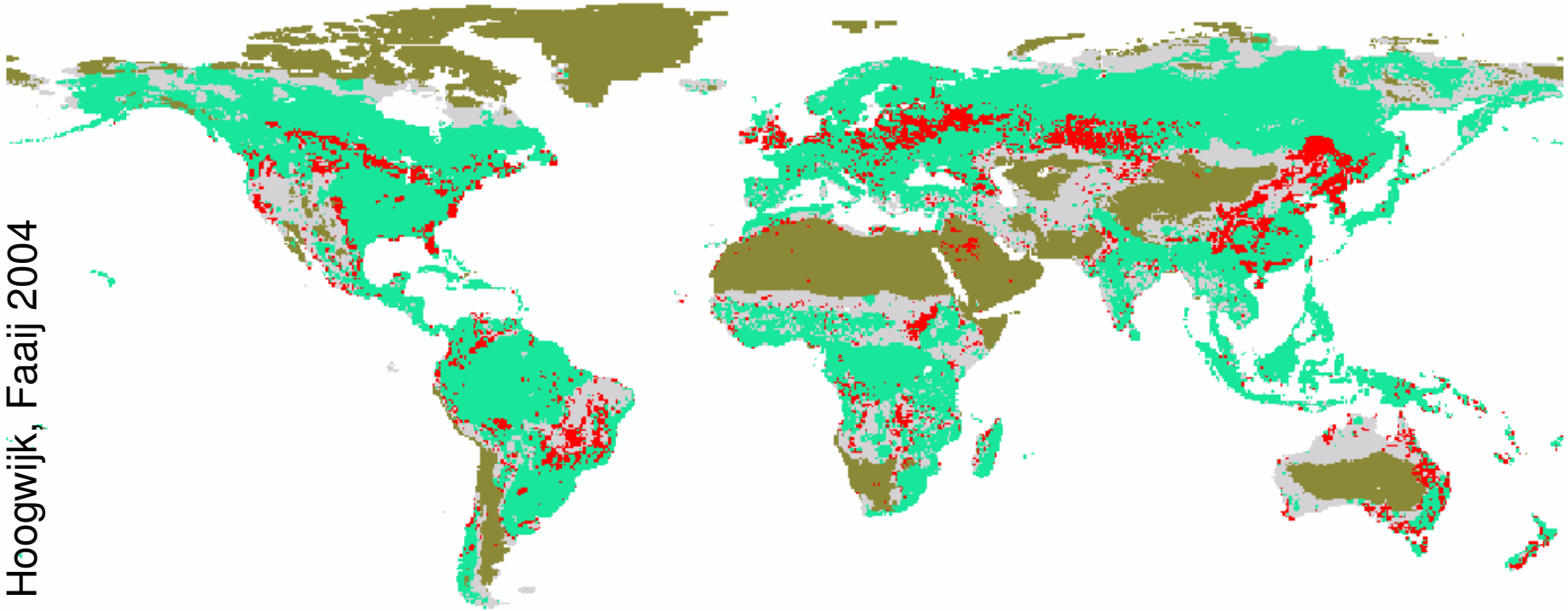

Source: Hoogwijk, Faaij 2004

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B1 2050

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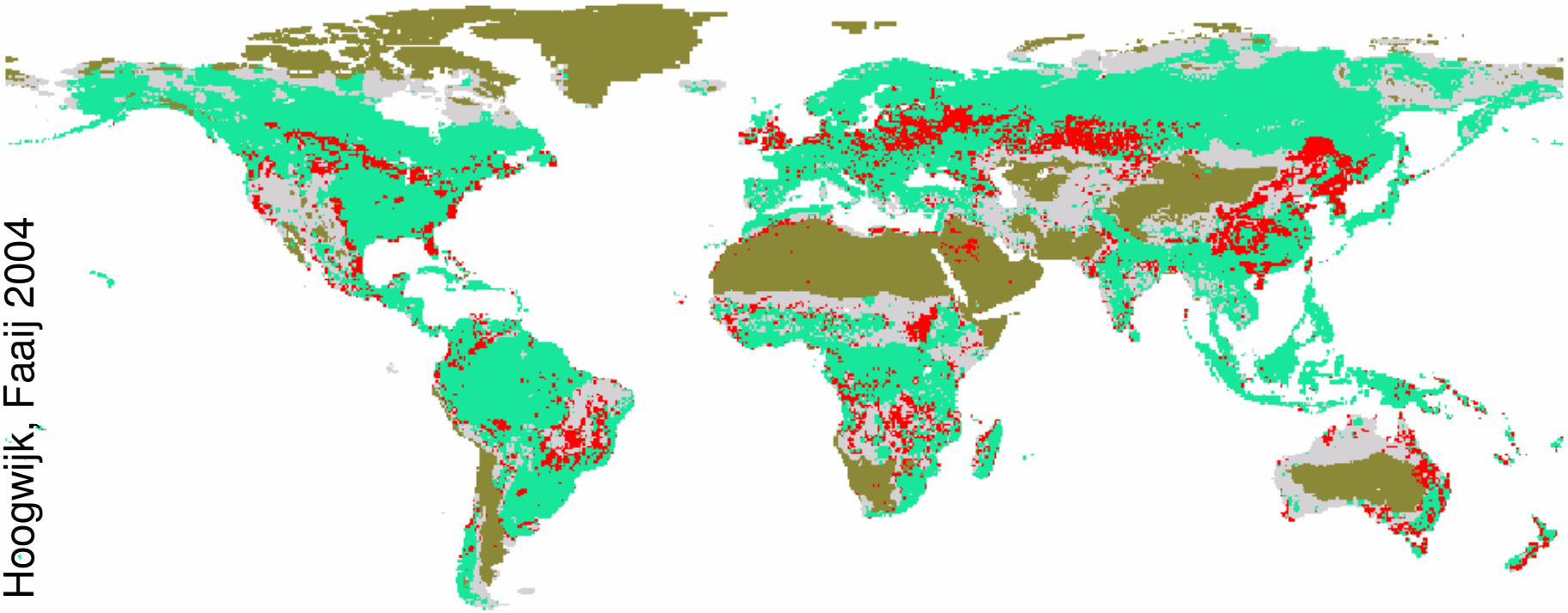

Source: Hoogwijk, Faaij 2004

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A2 2050

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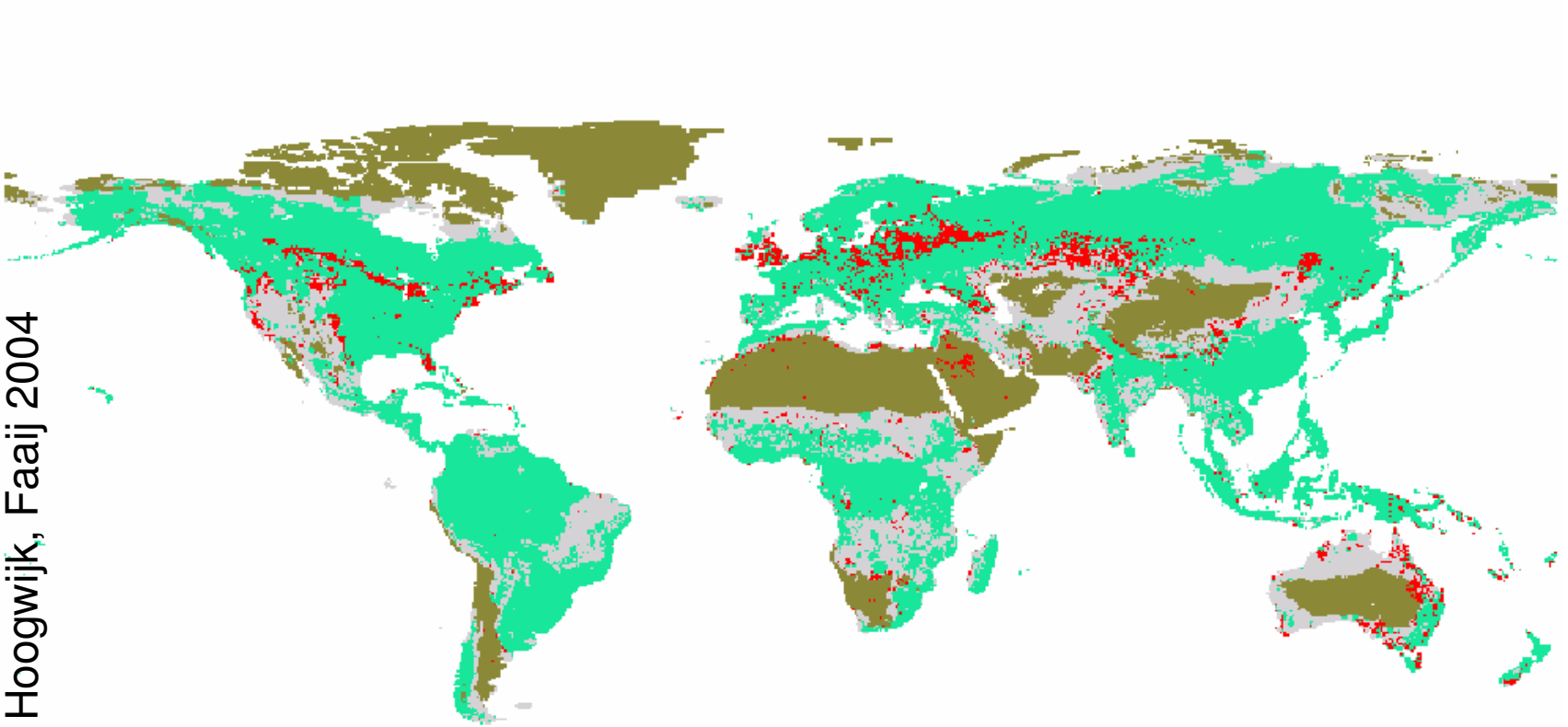

Source: Hoogwijk, Faaij 2004

A1 2050

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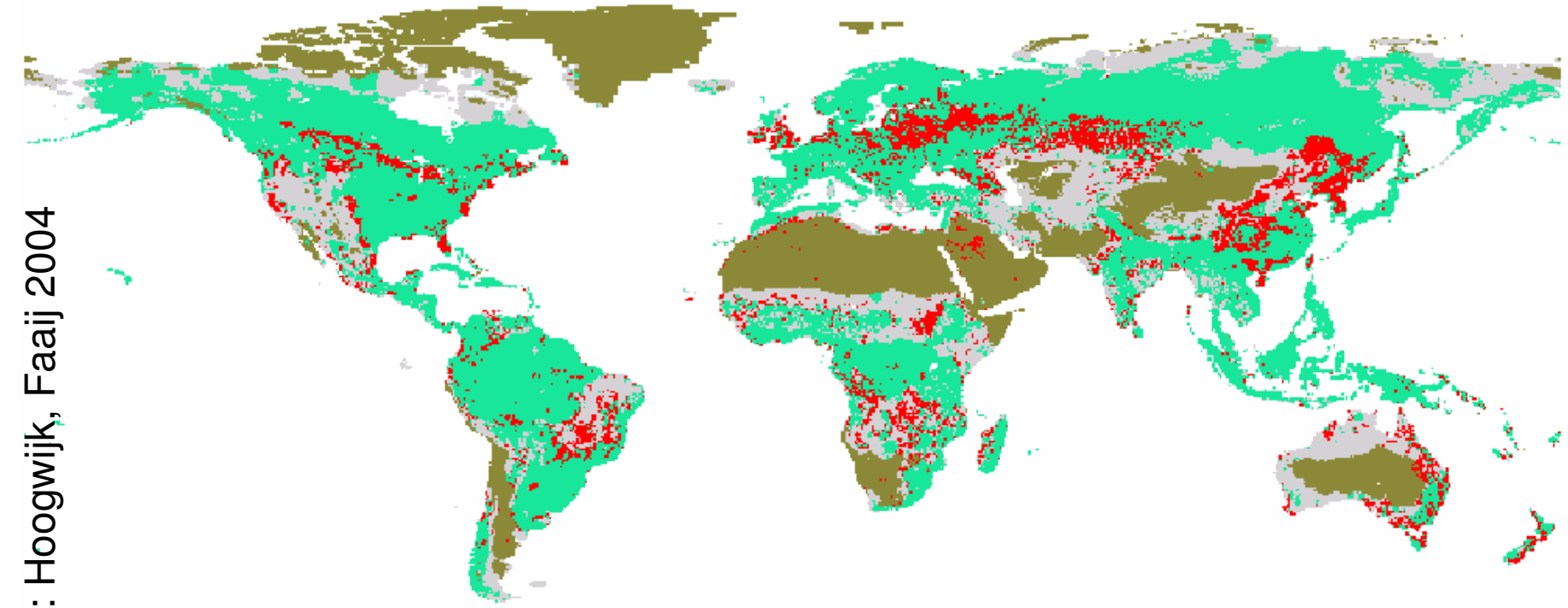

Source: Hoogwijk, Faaij 2004

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B2 2050

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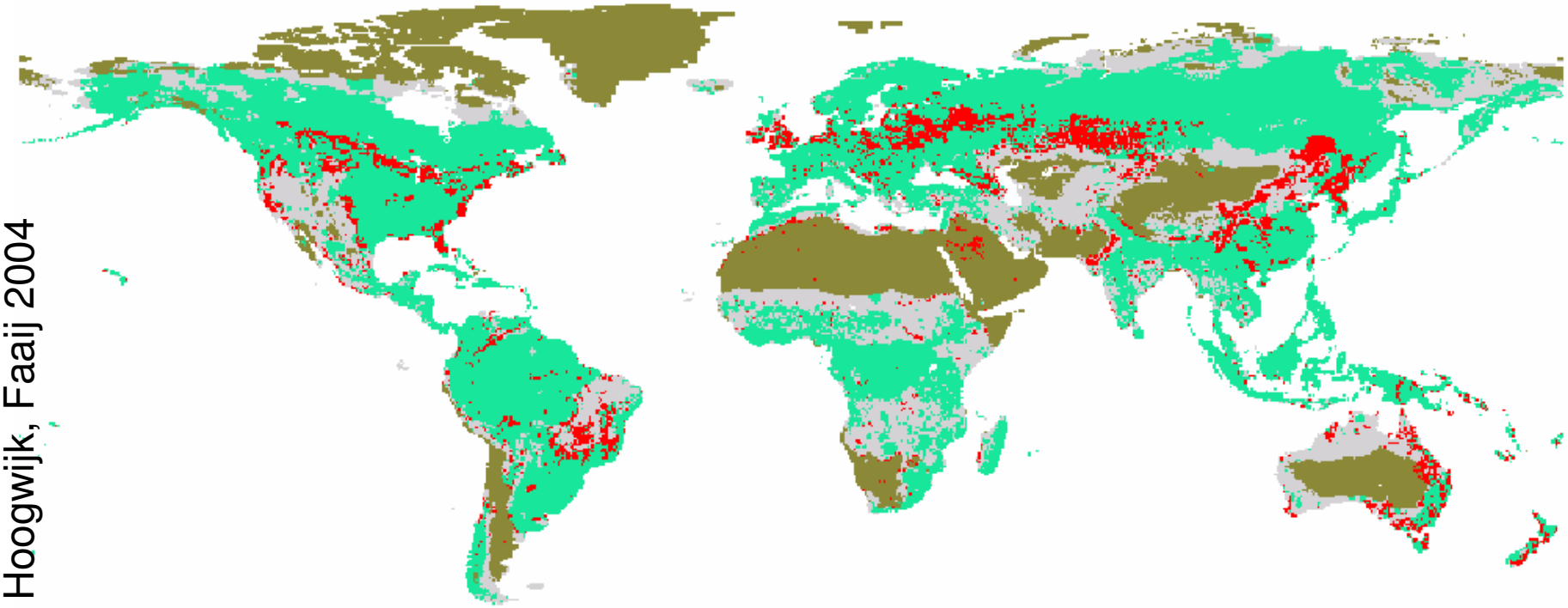

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B1 2050

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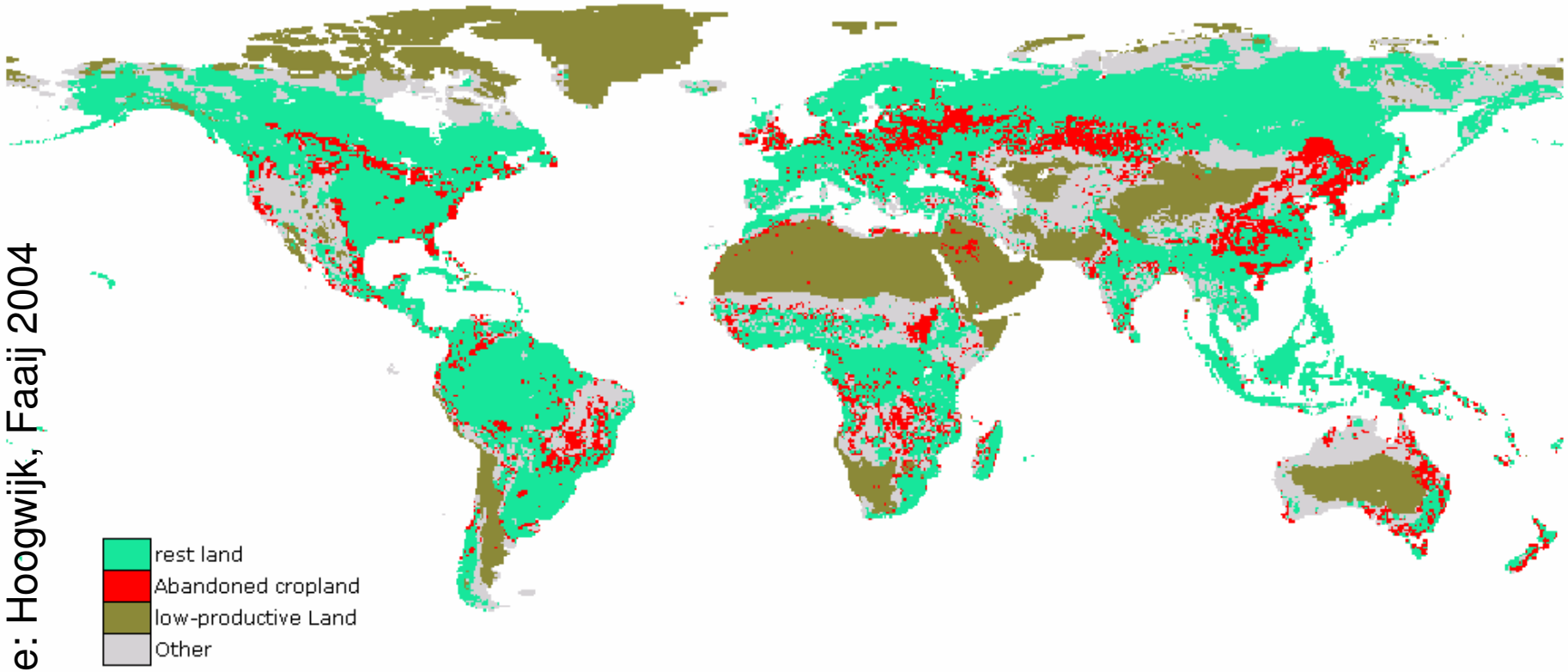

Source: Hoogwijk, Faaij 2004

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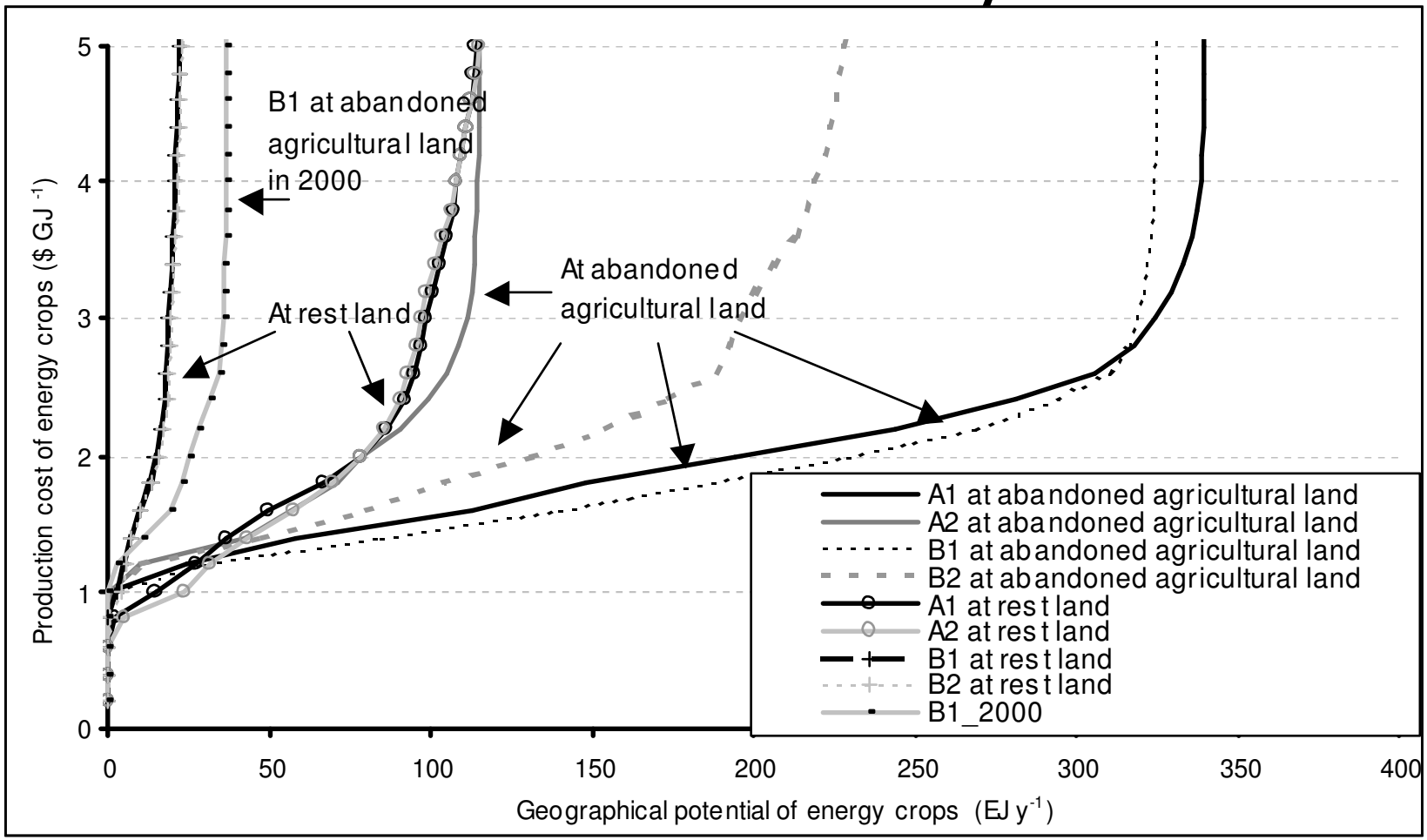
Global cost-supply curve for energy crops for four scenarios for the year 2050



Source: Hoogwijk, Faaij, 2004

Overall picture 2050

Biomass category	**Main assumptions and remarks**	**Potential bio-energy supply up to 2050.**
Agricultural land	Potential land surplus: 0-4 Gha (more average: 1-2 Gha).	0 – 700 EJ (average: 100 – 300 EJ)
Marginal lands.	On a global scale a maximum land surface of 1.7 Gha could be involved.	(0) 60 – 150 EJ
Residues agriculture	Estimates from various studies	15 – 70 EJ
Forest residues	Low value: figure for sustainable forest management. High value: technical potential. Figures include processing residues.	(0) 30 - 150 EJ
Dung	Use of dried dung. Low estimate based on global current use. High estimate: technical potential.	(0) 5 – 55 EJ
Organic wastes	Figures include the organic fraction of MSW and waste wood. Higher values possible by more intensive use of bio-materials.	5 – 50 (+) EJ
Total	Most pessimistic scenario: no land available for energy farming; only utilisation of residues. Most optimistic scenario: intensive agriculture concentrated on the better quality soils.	**40 – 1100 EJ** **(250 - 500 EJ)**

Essentials of future global biomass availability...

- Major contribution of bio-energy to global energy supply possible.
- But; major transitions required to exploit potentials.
- Improved food production systems & rate of deployment in DC's are essential.
- Use of marginal/degraded land & biomaterials.
- (Net) biomass supply per region strongly determined by local factors; large differences between regions.

Phases in bio-energy use and market development…

1. Waste treatment and process residues; use on site, low costs.
2. Local use of (more expensive) forest and agricultural residues; some infrastructure development.
3. Regional biomass markets, larger scale utilisation, increasingly complex logistics; supportive policies needed.
4. National markets with complex set of suppliers and buyers; often increased availability.
5. Increasing scale, cross-border flows; role for cultivated biomass; bilateral activities.
6. ***Global commodity market; pricing mechanisms; complex interlinkages with existing markets (food, forestry, feedstocks)?***

International bio-energy markets developing fast…

- Growing bio-energy demand and international supply chains create unique opportunities for biomass producing regions.
- Solid biofuels trading develops in bilateral setting (Canada, Russia, agricultural residues); bio-ethanol entered first phases commodity market trading; *‘wild west phase”*
- Overexploitation should be avoided and fairtrade principles implemented.
- www.fairbiotrade.org (IEA Task 40 on Sustainable International Bio-energy Trade).

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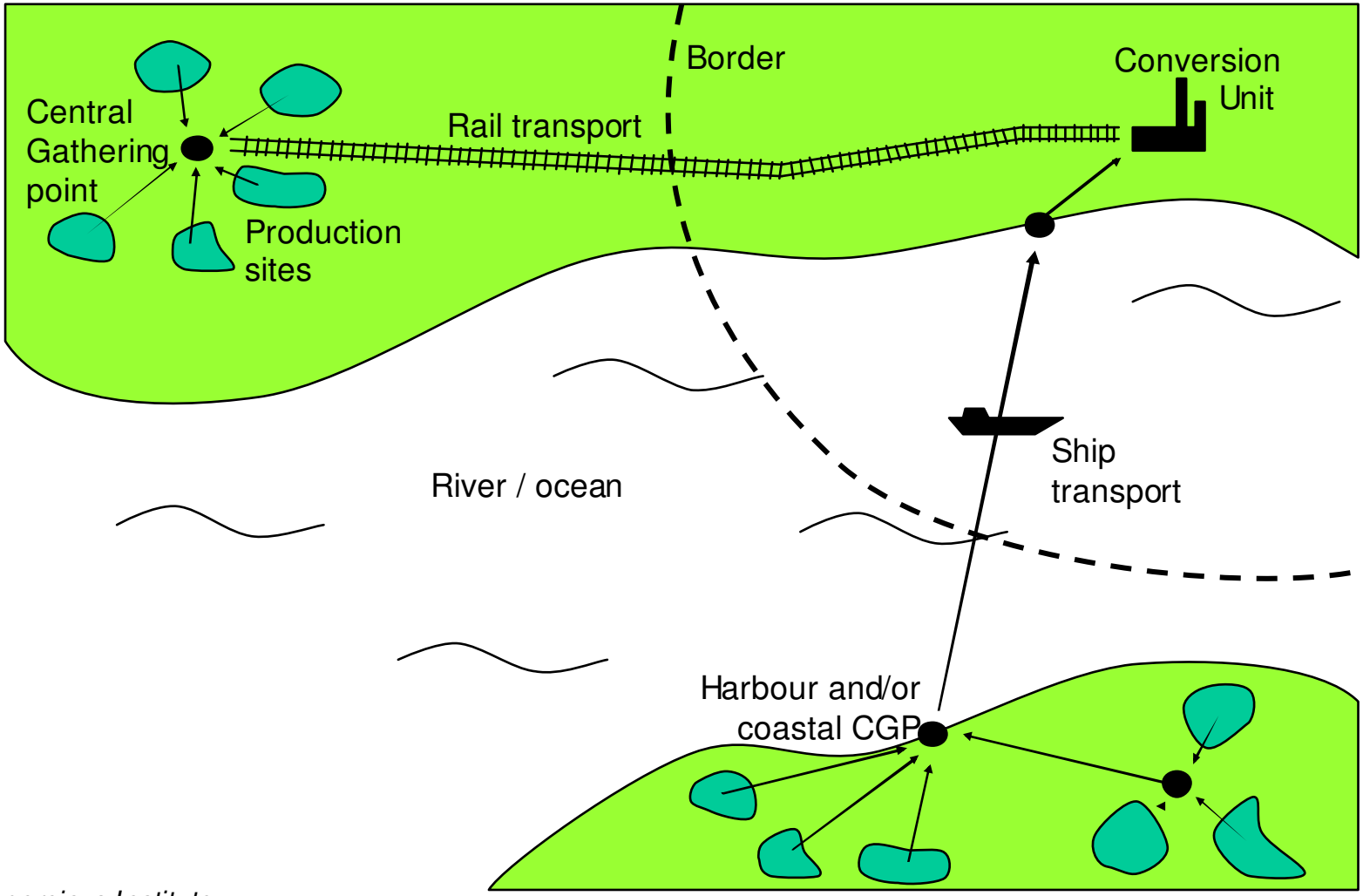
International bio-energy logistics



Source: Hamelinck, Faaij, 2003

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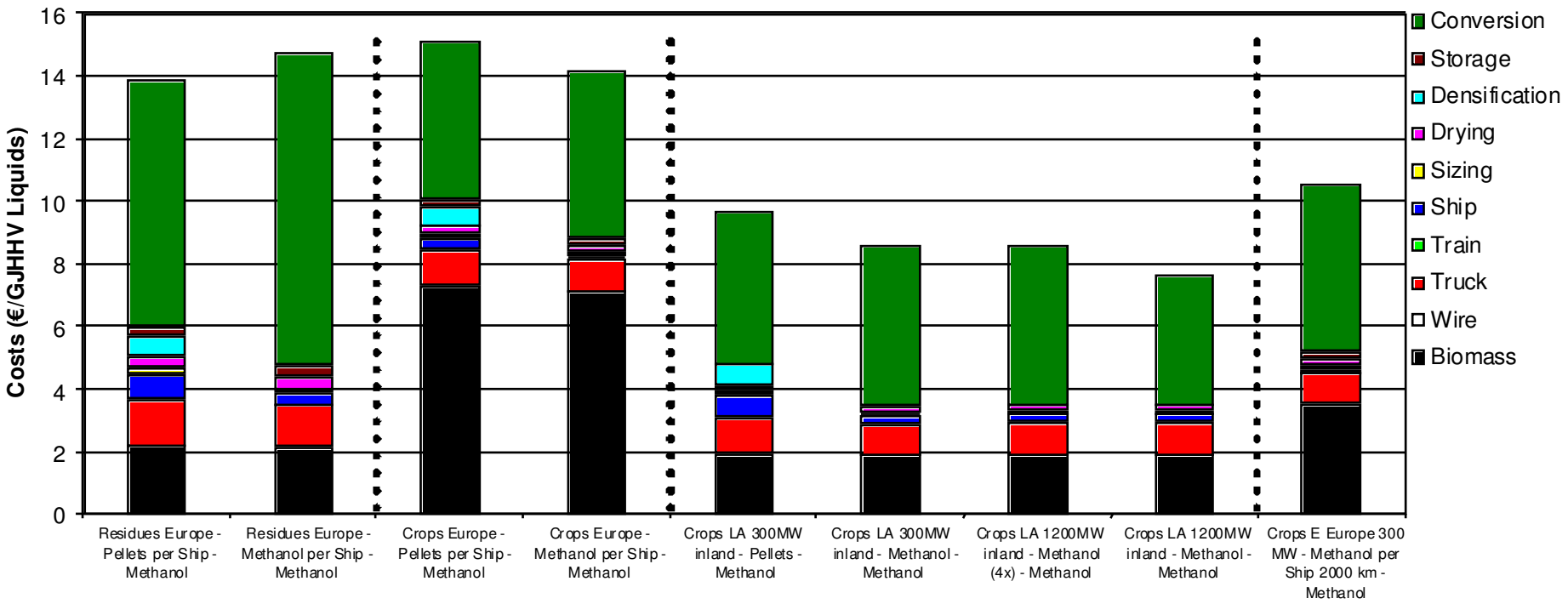
Bio- methanol to Rotterdam harbour; international transport is not the showstopper...

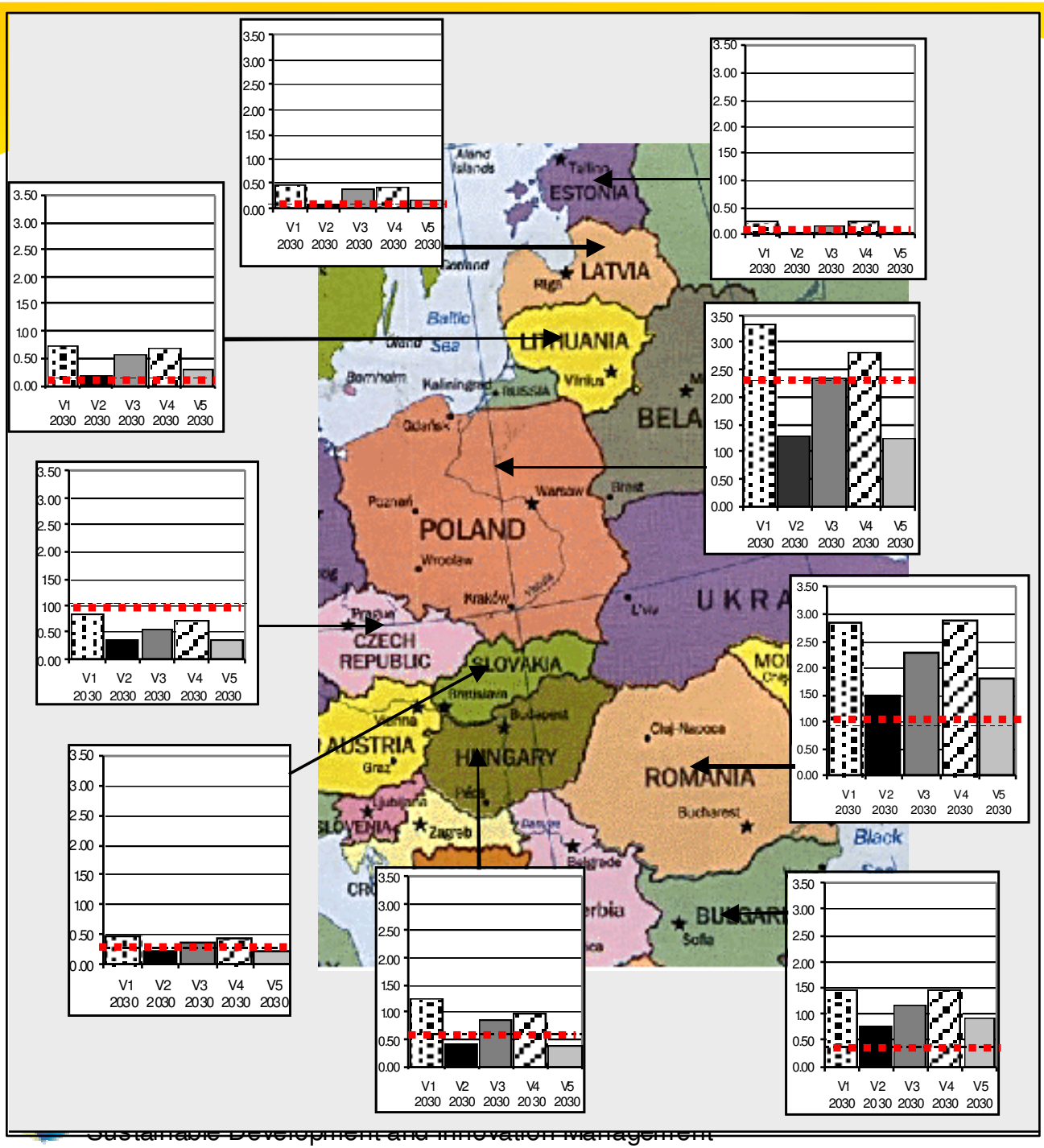


Hamelinck & Faaij, 2003

Scenarios for CEEC; 2030

Scenario	V1	V2	V3	V4	V5
Name	**Full trade / High Tech**	**Current**	**CAP reforms**	**Protected Europe / High tech**	**Ecological**
Story line	Full international trade, free market	CEEC lacks behind WEC in agricultural and economic development	CAP reforms are implemented	Highly protected Europe (closed market)	Ecologically oriented Europe
Production system (FCE = feed conversion efficiency)	**High input advanced technology**, FCE based on WEC 2030	**Current** production system, FCE based on CEEC current situation	**High input**, FCE based on OECD 2030	**High input advanced technology**, FCE based on WEC 2030	**Ecological** (intermediate) input system, FCE based on current situation
Allocation	**CEEC**, division over countries	Country, division over Nuts-2	Country, division over Nuts-2	Country, division over **Nuts-3**	Country, division over Nuts-2

Van Dam et al., 2004

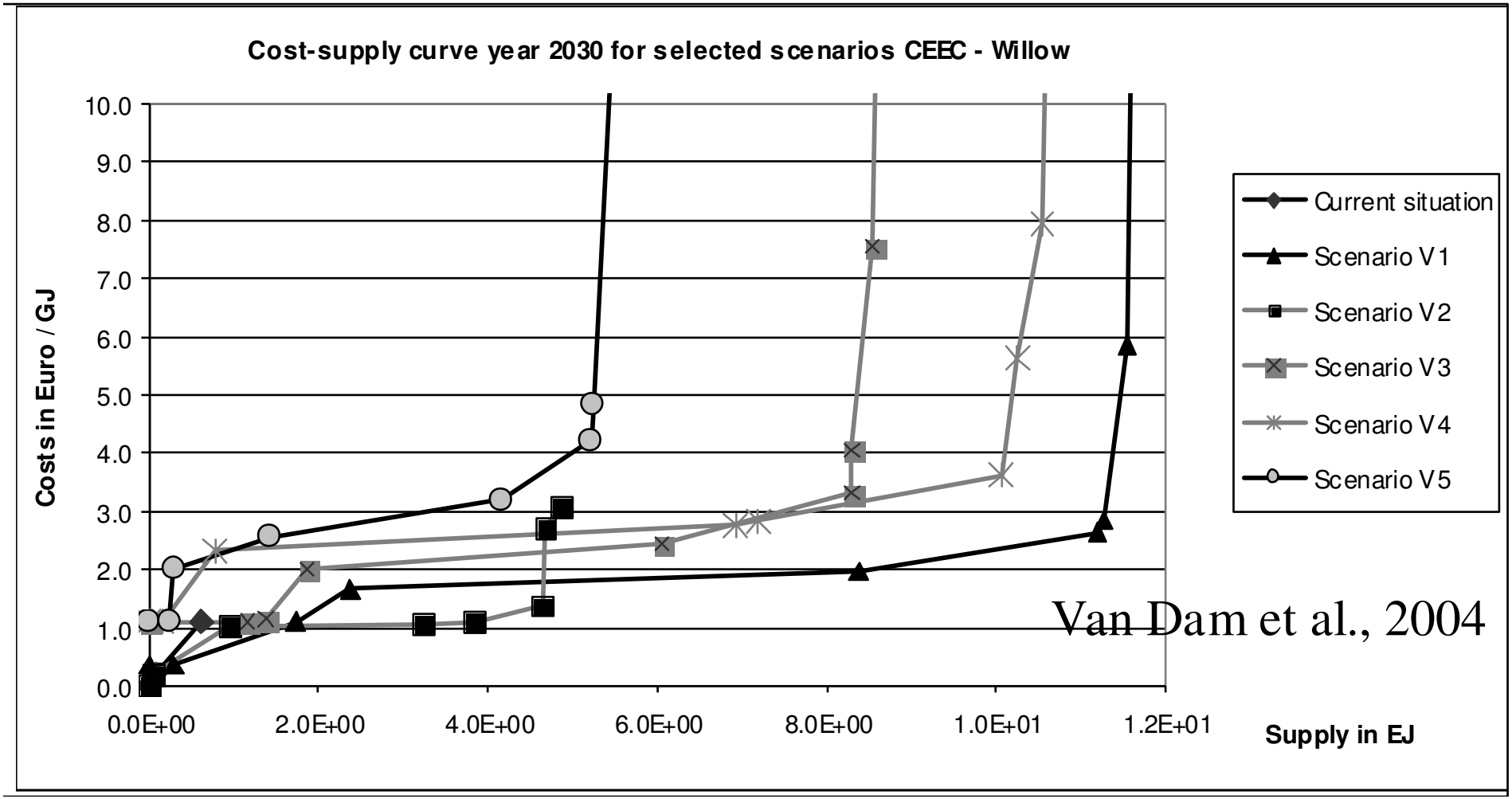


Biomass potential on country level (in EJ). Residues + energy crops (Willow)

Red lines: current final energy consumption on country level

Van Dam et al., 2004

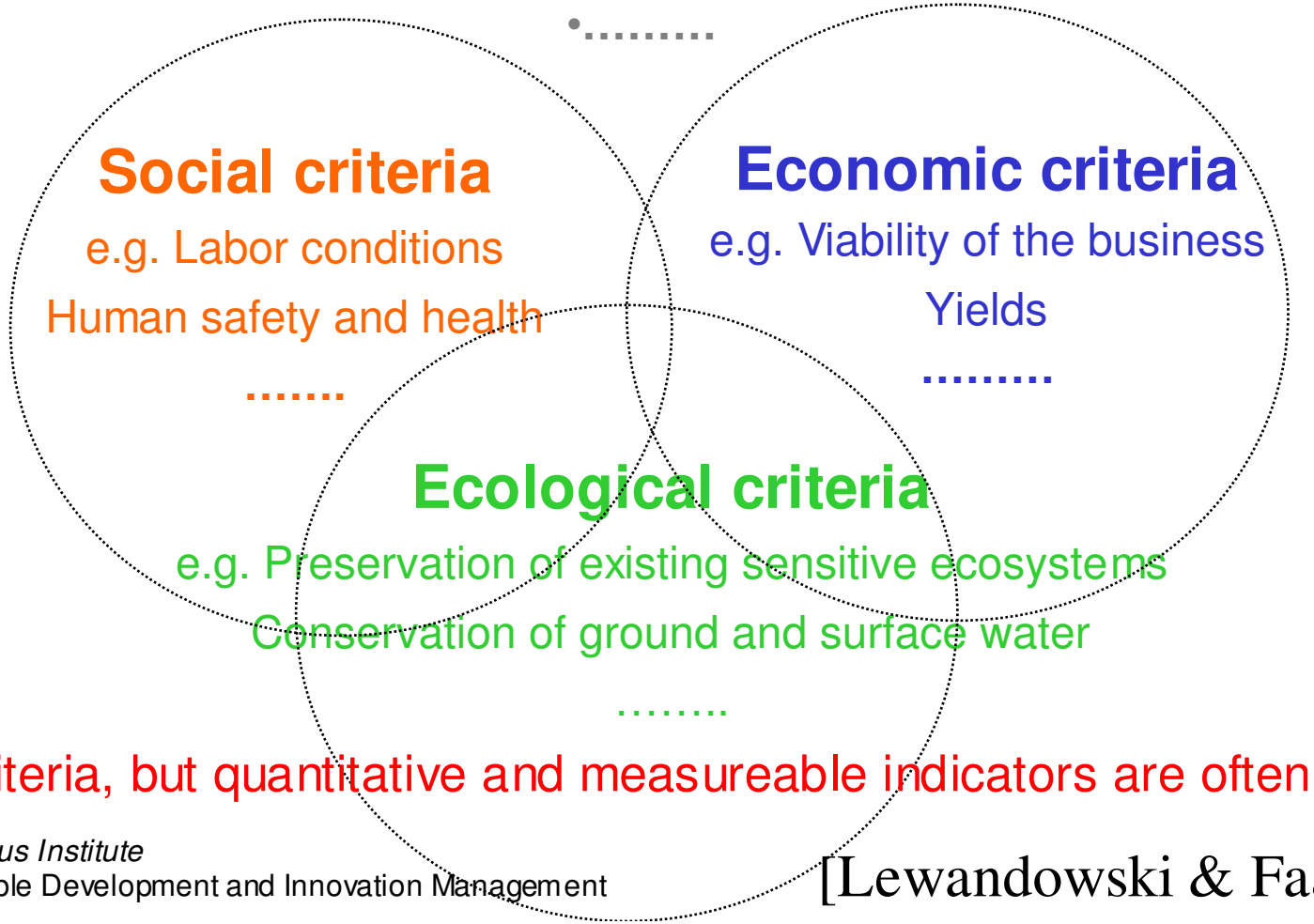
Cost-supply curve for all CEEC (SRC-Willow)



Areas of concern relevant for sustainability of the biomass production and trading chains

General criteria

- e.g. Traceability
- Avoidance of leakage effects
- .....



➡Many criteria, but quantitative and measureable indicators are often missing

[Lewandowski & Faaij, 2004]

Operationalisation of sustainability criteria

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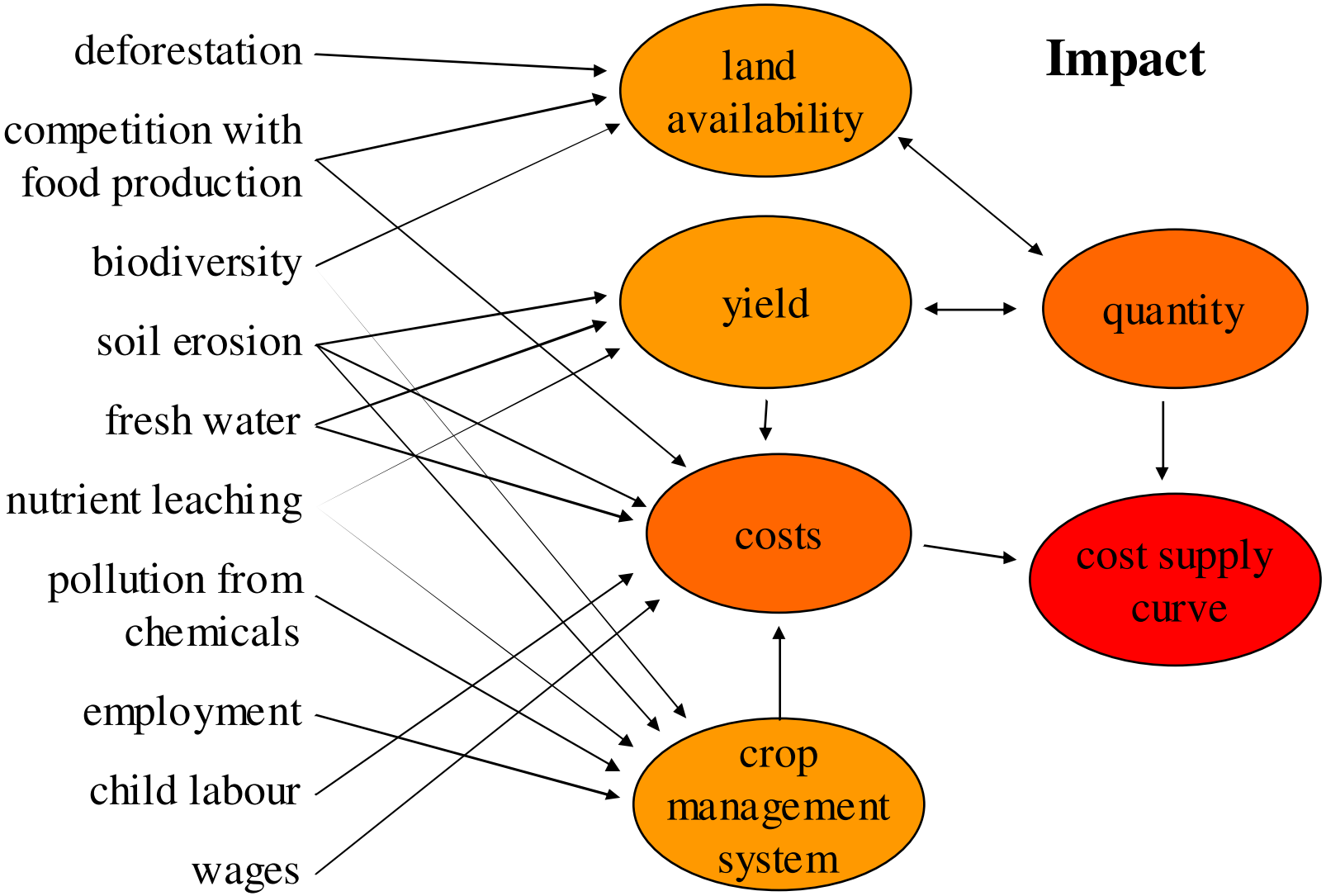


[Smeets et al., 2005]

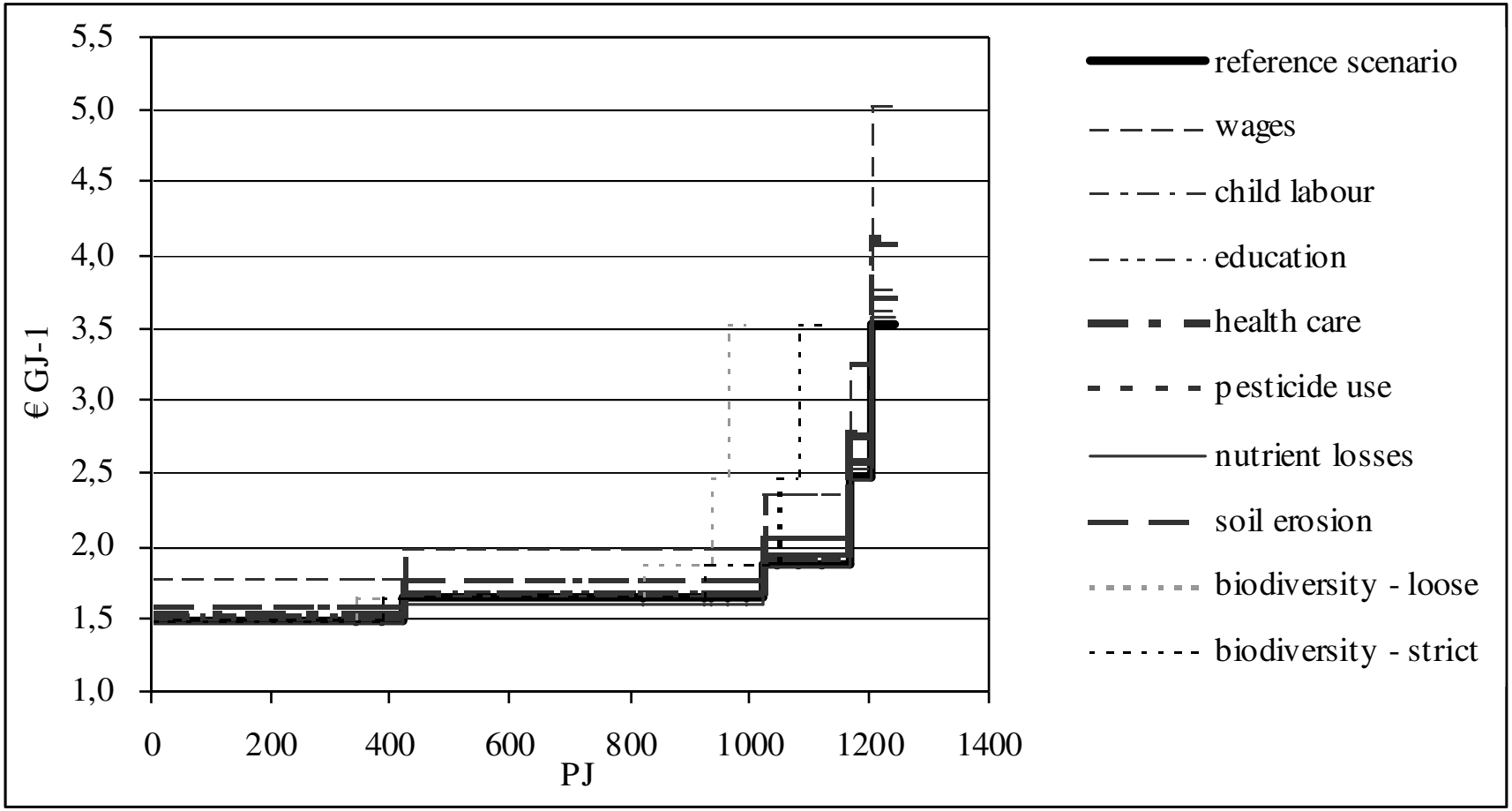
Regional selection

- potentials on short term (2015), modest assumptions:
- Ukraine: central region poplar
- Brazil: southern region eucalyptus

	crop yield increase	feed conv.eff. increase	surplus agric. area	surplus agric. area	bioenergy crop potential
			(%)	(mln ha)	(PJ)
Brazil	2.2	1.5	19	3.3	1250
Ukraine	1.9	1.0	13	7.7	1500

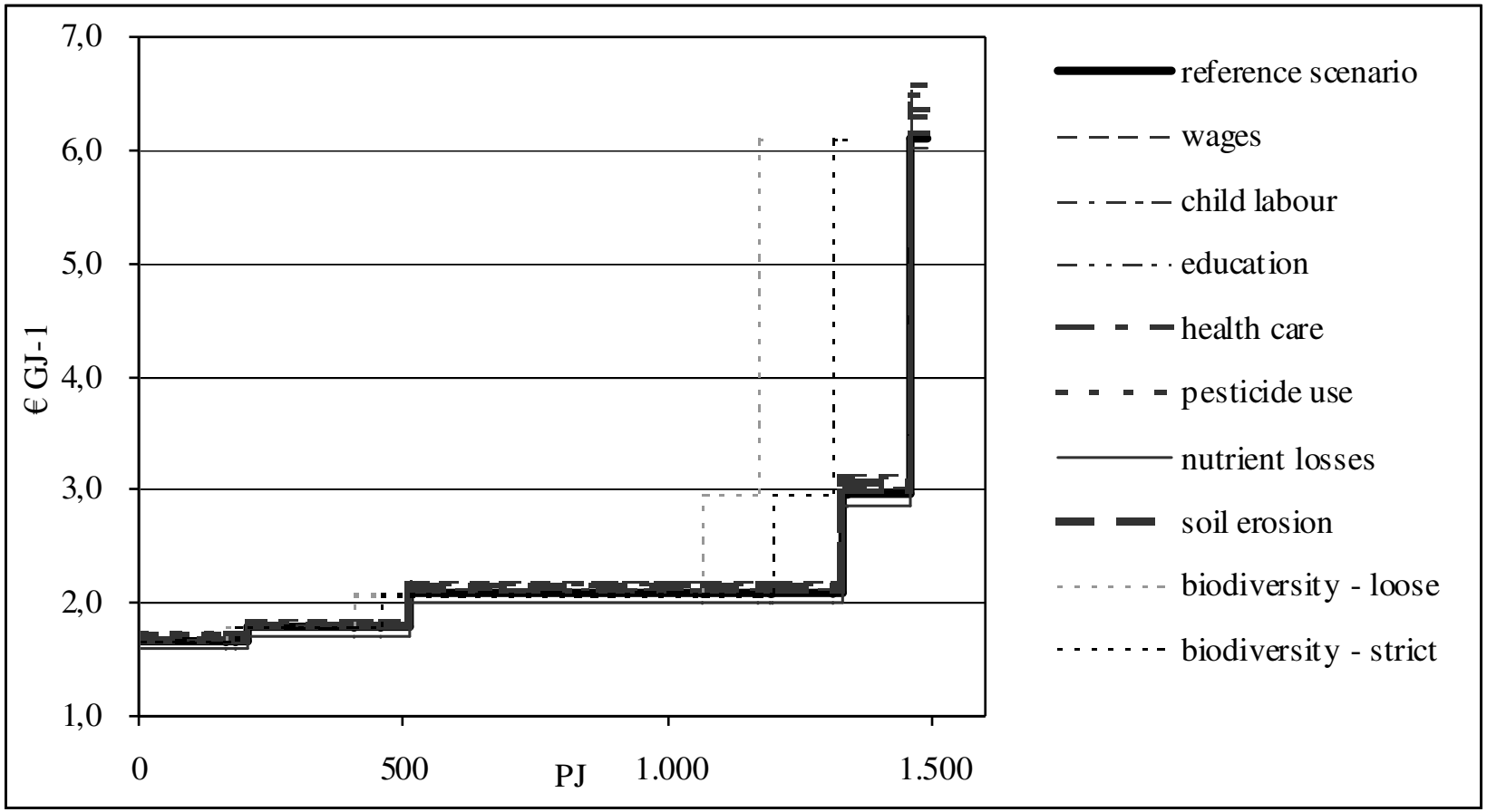
[Smeets et al., 2005]

Cost supply curve
Brazil with sustainability demands



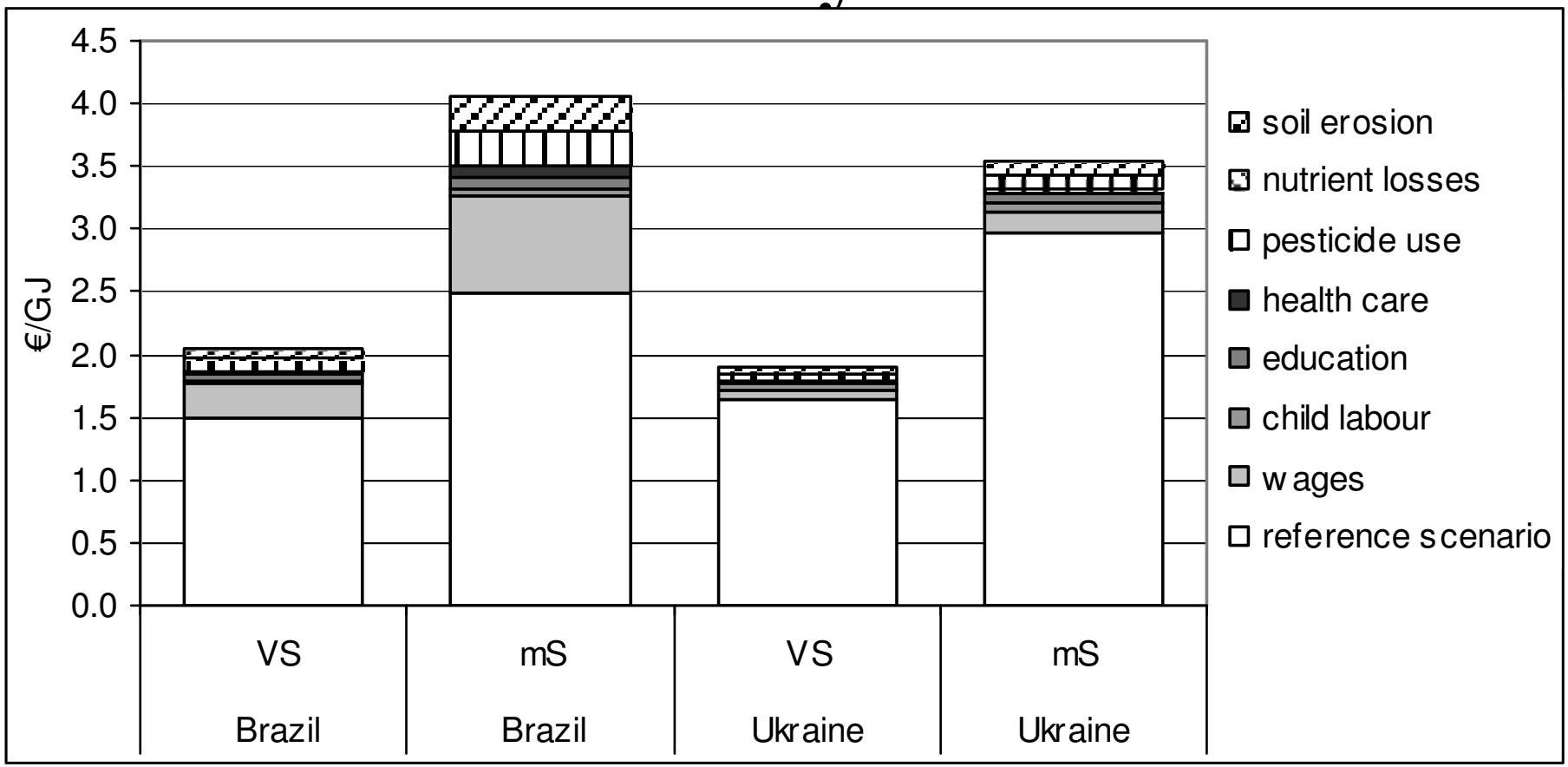
[Smeets et al., 2005]

Cost supply curve Ukraine with sustainability demands



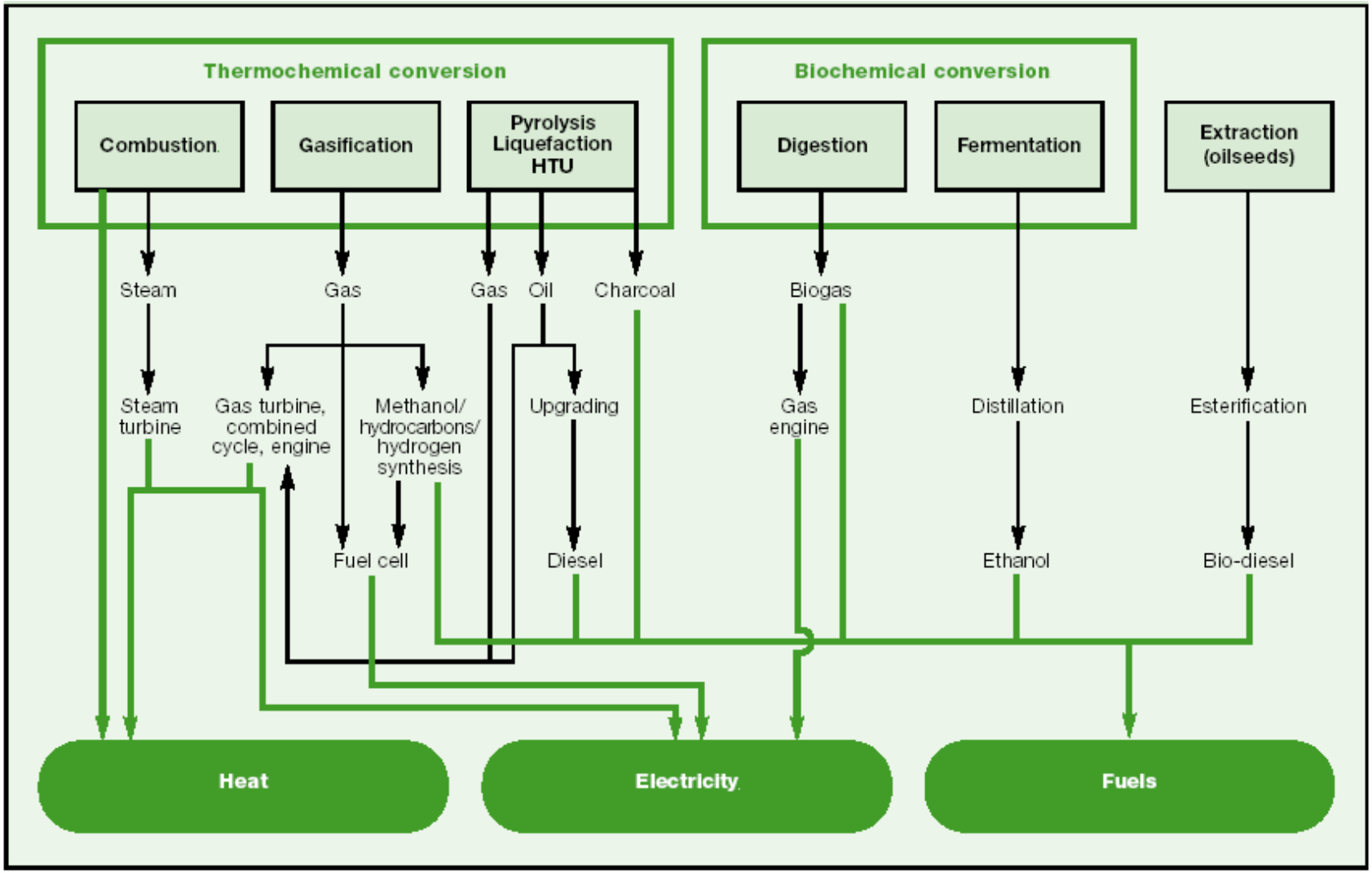
[Smeets et al., 2005]

Indicative cost impacts of applying sustainability criteria…

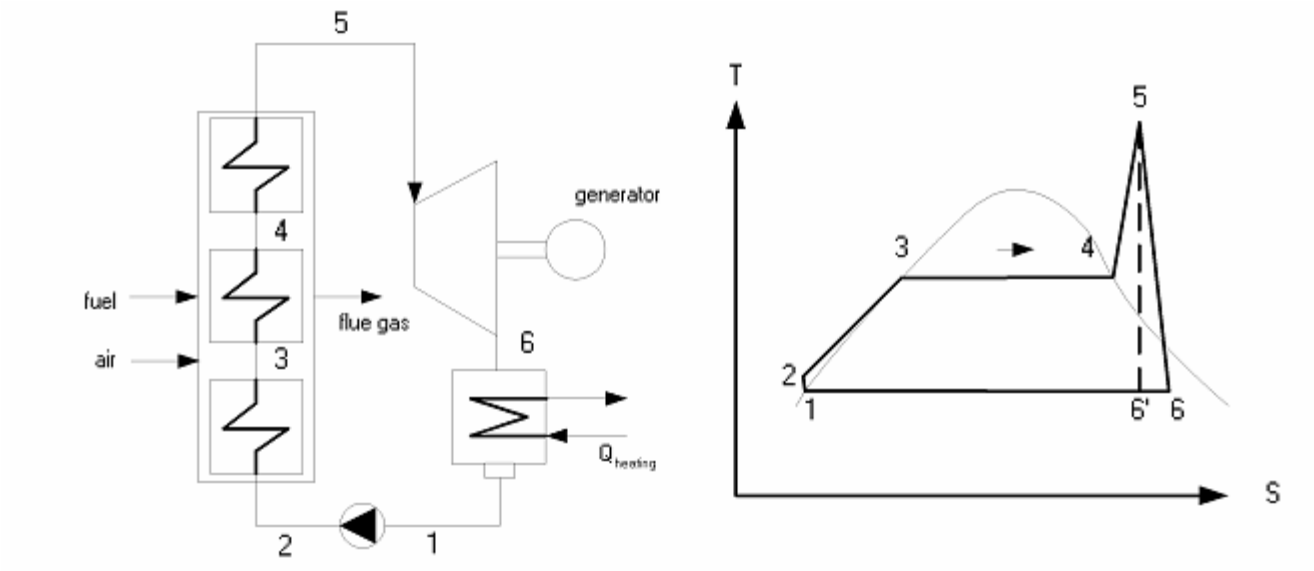


[Smeets et al., 2005]

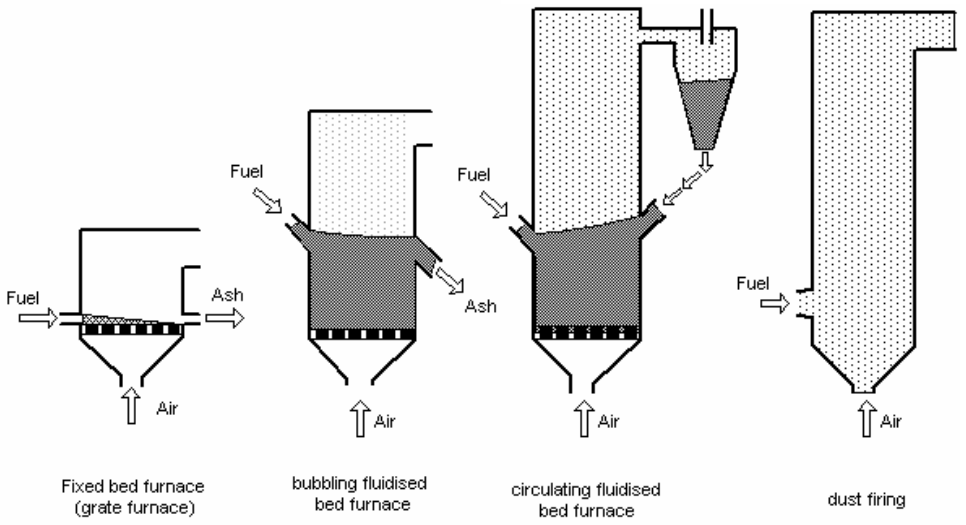
Key bioenergy utilisation routes



Combustion; workhorse of bio-energy…

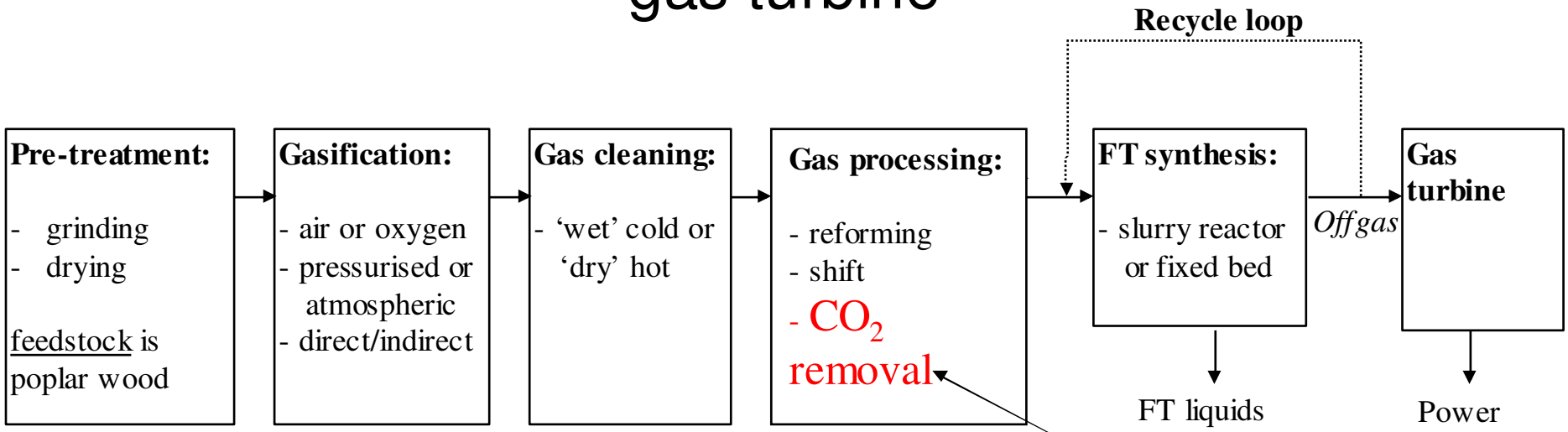


Efficiency: from 20 – 40%
CHP: 60 - <80%
Capacity: 20 – 250 MWe …
Economics OK with residues



General process scheme

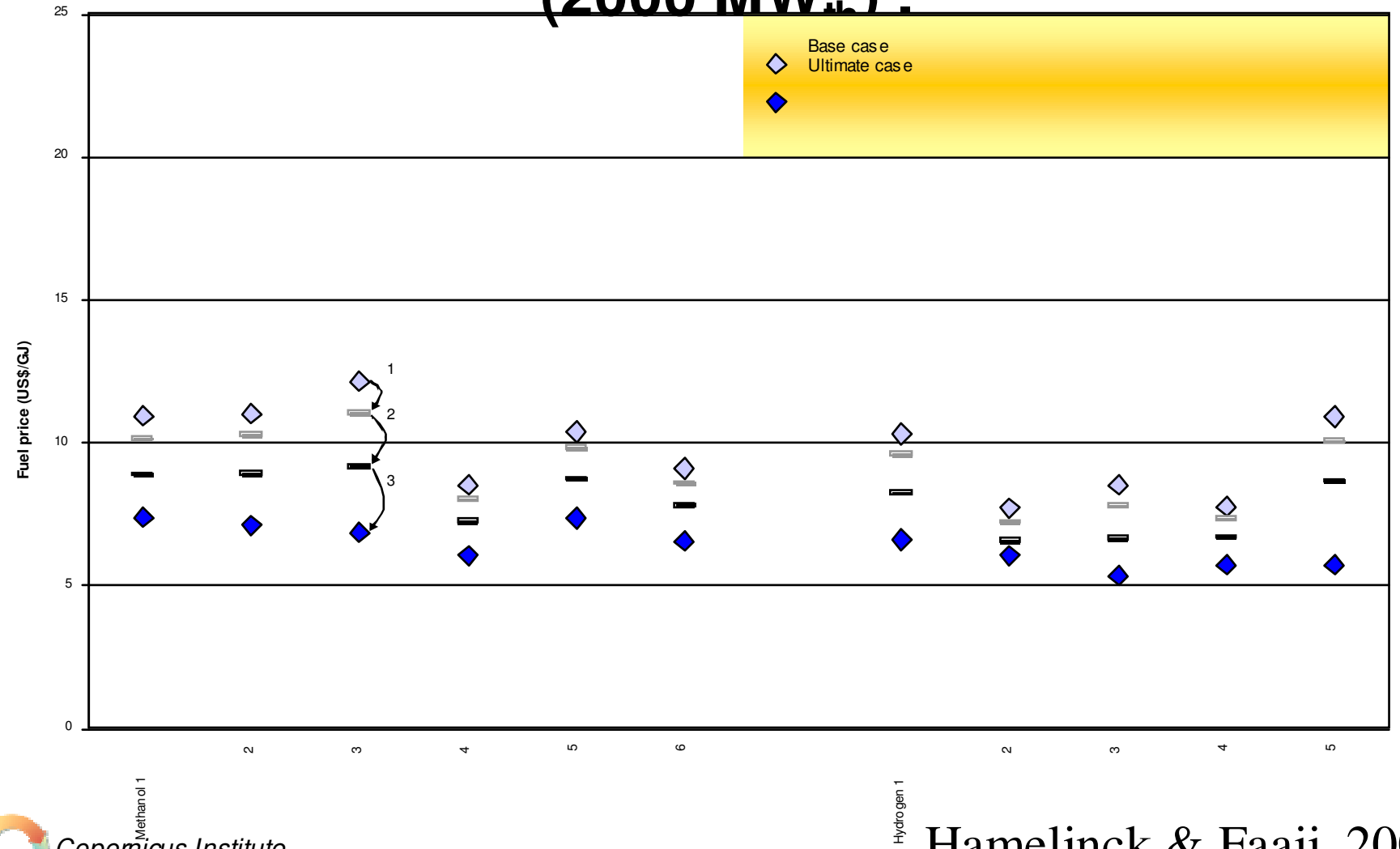
Biomass (& coal) gasification to FT liquids - with gas turbine



Major investments in IG-FT capacity ongoing in China **right now**:
- Reducing dependency on oil imports!
- Without capture strong increase in CO2 emissions…

About 50% of carbon!

Costs & cost reductions: (1) biomass costs 15% lower, (2) technological learning (3) scale increase (2000 MW_{th}) .



Hamelinck & Faaij, 2002

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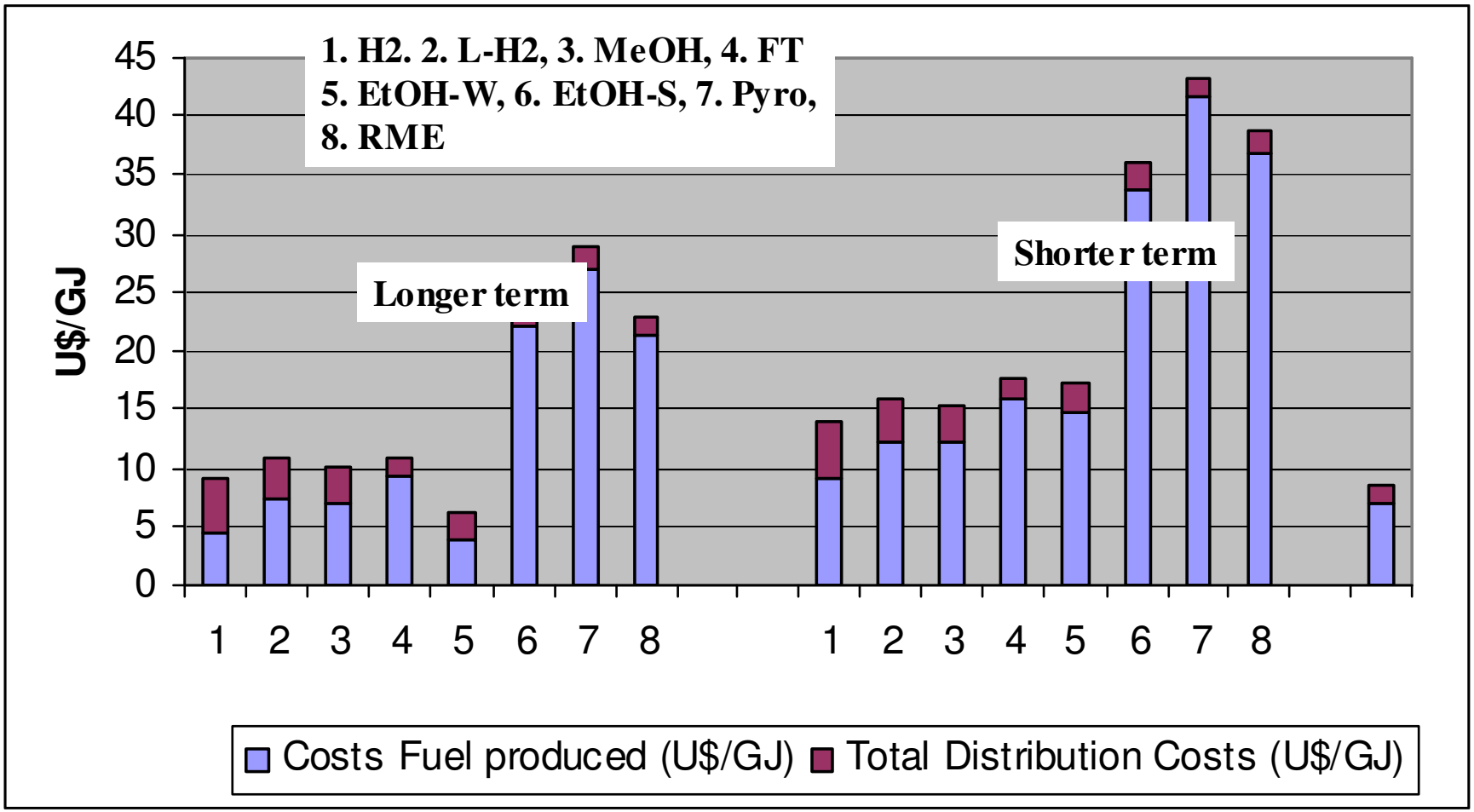
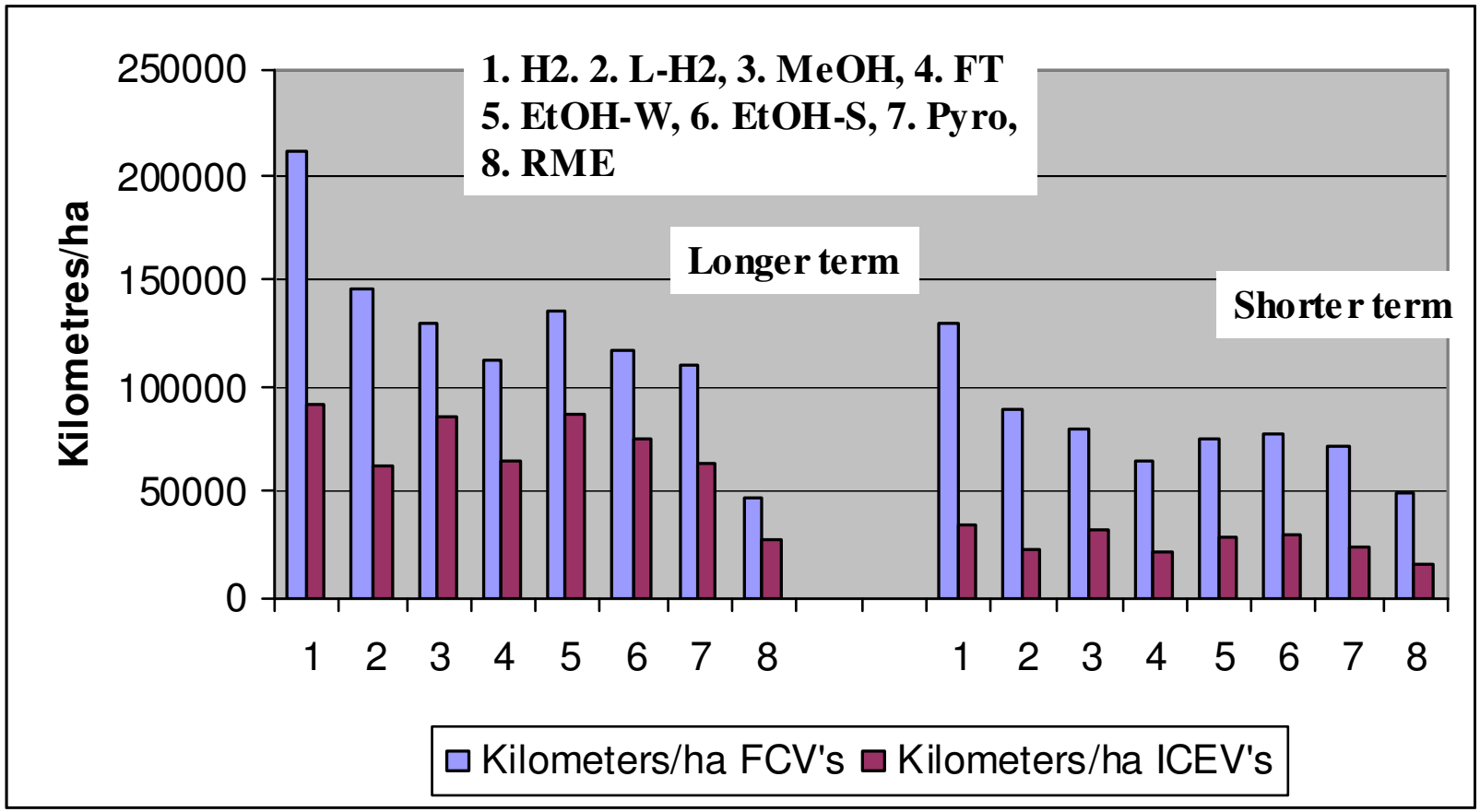
Costs per GJ fuel delivered at the car



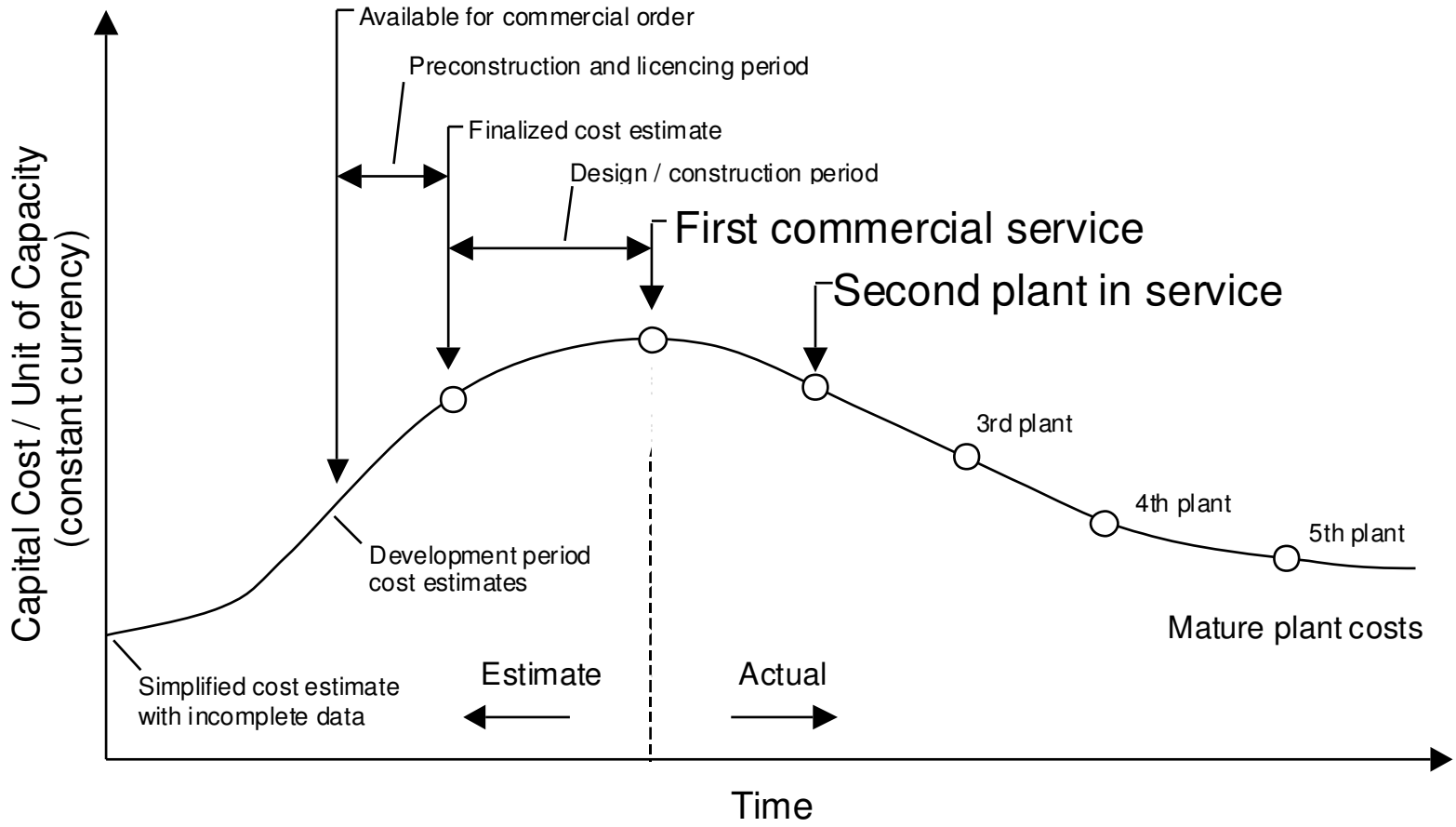
Reference oil price ~ 25 U$/barrel

Biofuel chains; kilometres per hectare.



Faaij & Hamelinck, 2002

Generic learning curve for (e.g.) power plants; 'time' *means decades*



Ethanol from sugar cane…

J. Goldemberg et al. / Biomass and Bioenergy 26 (2004) 301–304

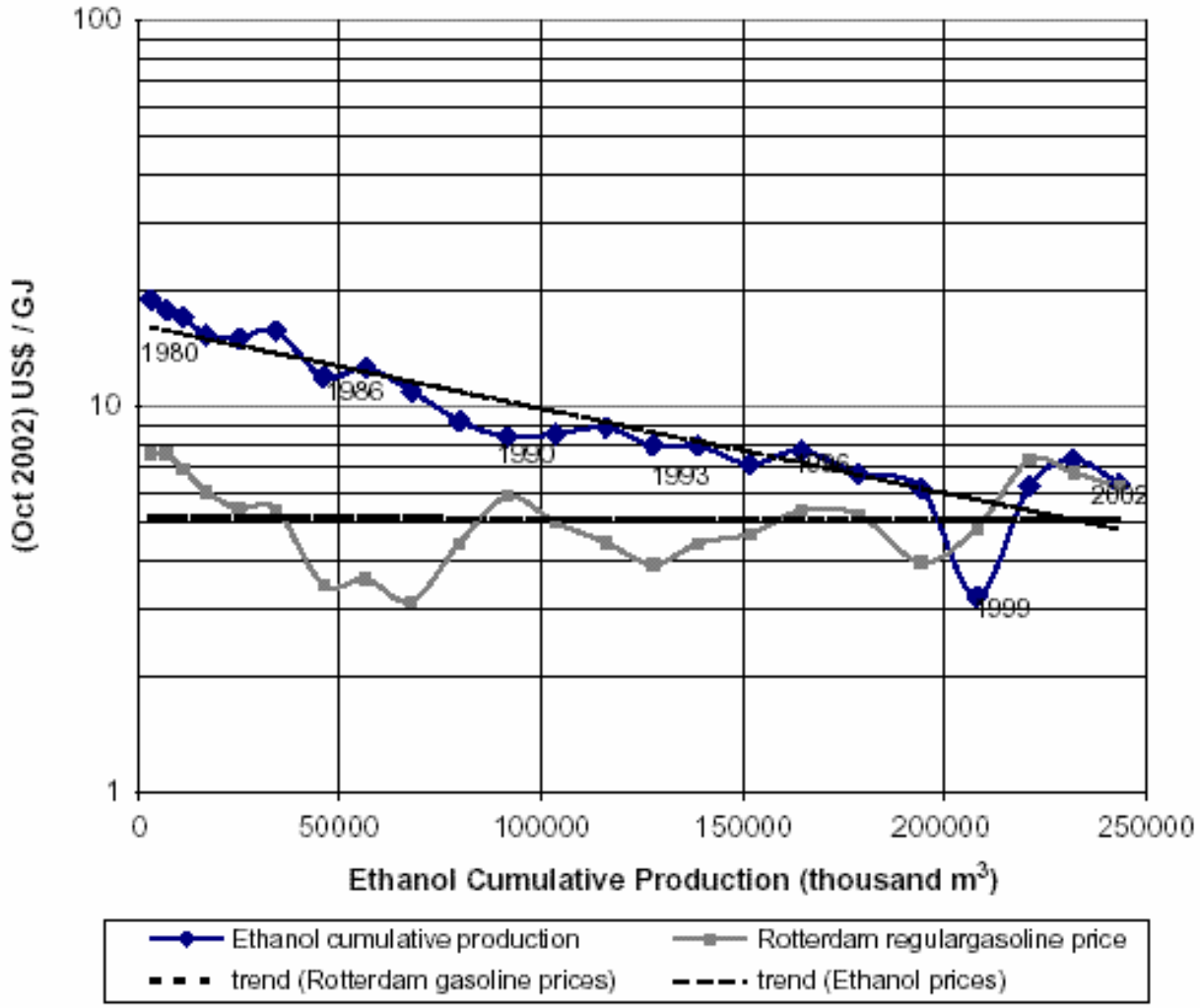
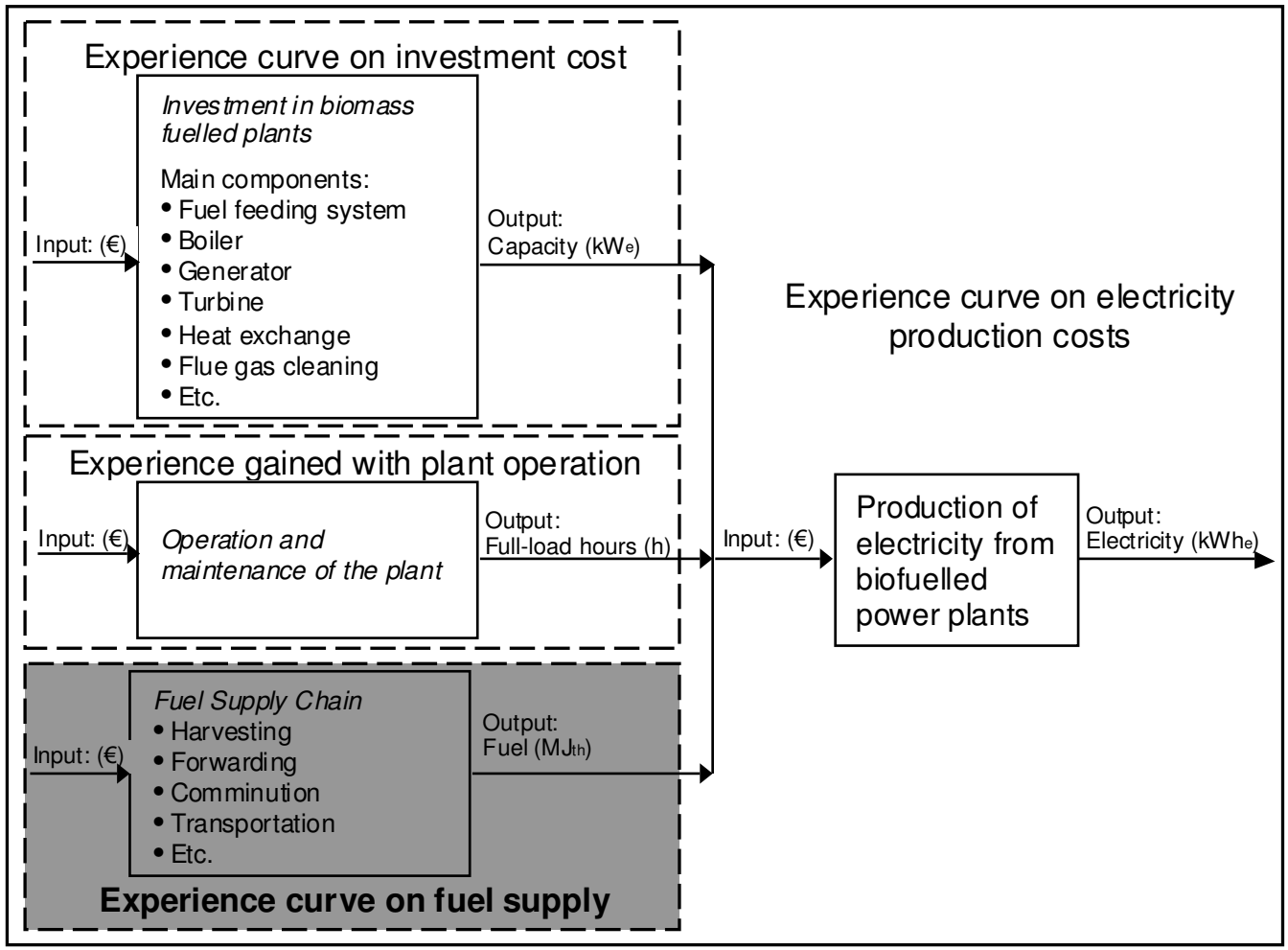


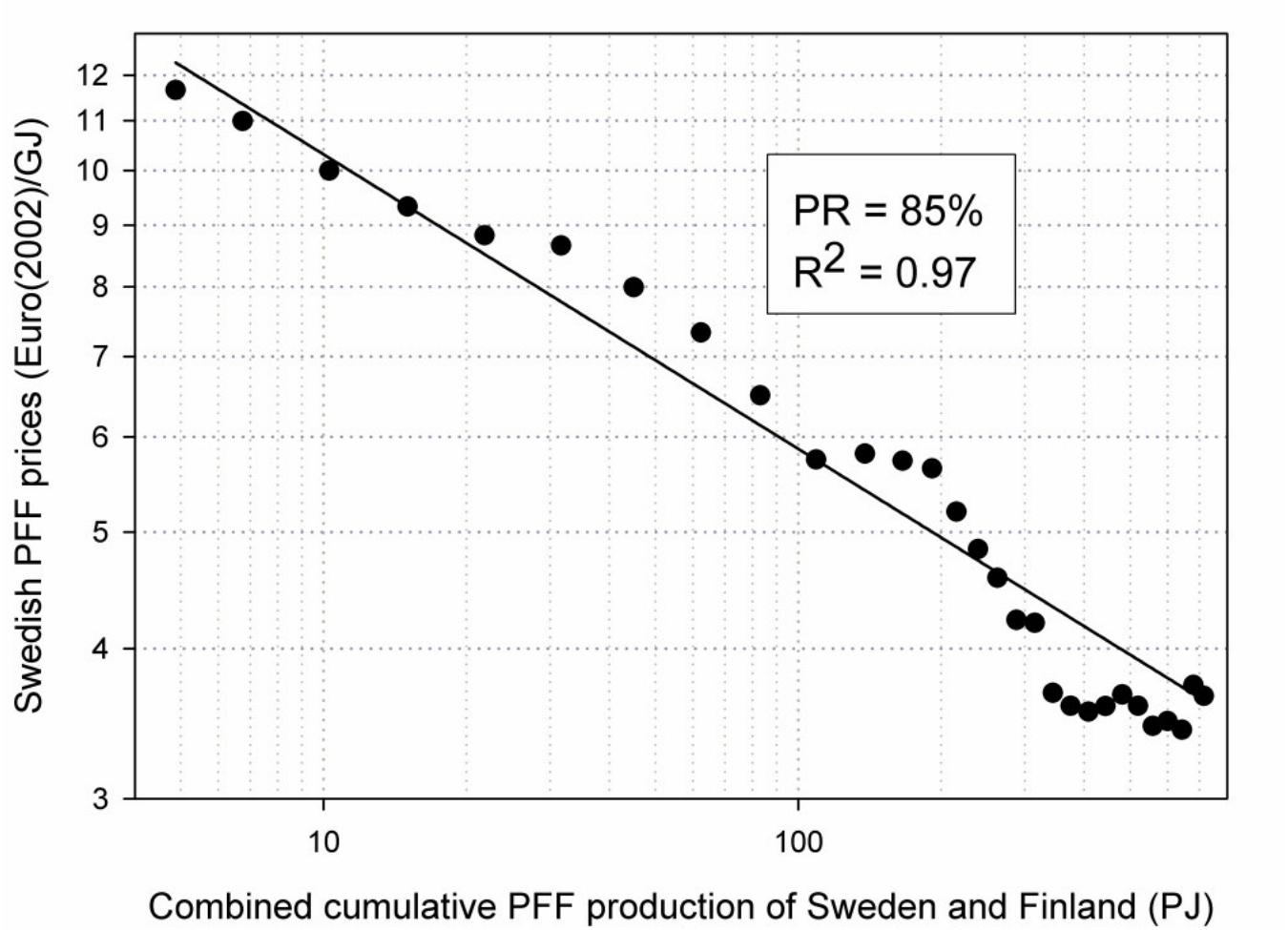
Fig. 2. Ethanol and gasoline prices.

Total learning system for biomass-fuelled power plants producing electricity



Source: Junginger et al., 2005

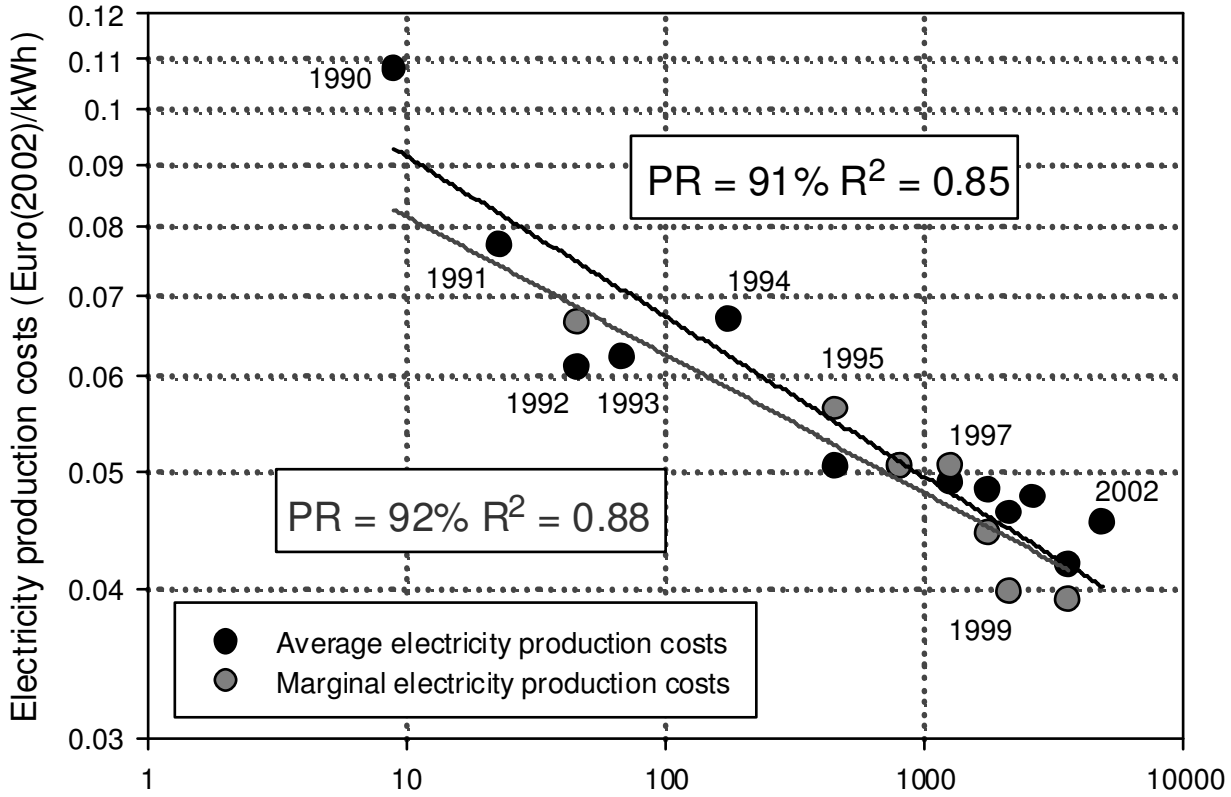
Experience curve for Sweden and Finland combined, between 1975 and 2003.



Source: Junginger et al., 2005

Experience curve for the average and marginal production cost of electricity from Swedish biofuelled CHP plants from 1990-2002

Source: Junginger et al., 2005



Closing remarks

- Large, economic biomass potentials (but needs complex, sustainable, development and a working international market).
- Competitive biomass-technology combinations within reach for the world market (but needs serious, consistent development and market introduction).
- Bright future; but policy needs to choose and coordinate (agriculture, trade, climate, energy and development are interlinked here).

IEA Task 40 Sustainable International Bio-energy trade

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- **Members:** Netherlands, Sweden, Norway, Brazil, Finland, Canada, UK, Italy, Belgium (Germany?)
- **Affiliated international bodies**
  - FAO, World Bank; (interest from UNECE)

www.fairbiotrade.org:

- Detailed activities
- Background information
- Results (e.g. country reports, analyses)
- Events (e.g. at FAO and World Bank).