



European Biomass Industry Association

General framework of European Initiatives for Biofuels

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Context

Several issues relate to the valorisation of biomass resources :

- Agricultural policies and food production
(global and structural food overproduction in EU)
- Need of energy sources
(indispensable for economic development)
- Water availability
(emerging problem)
- Desertification
(+6 million ha/year around the world)
- Market liberalisation and globalisation





Introduction

A few definitions:

Biomass: organic matter produced through the photosynthetic process

Bioenergy: refers to the overall technical means through which biomass is produced, converted and used

Biofuels: energy carriers which can be found under different forms (solid, liquid, gaseous) and derived from biomass feedstocks (mainly from dedicated starch, sugar, oil or lignocellulosic crops, or agro-forestal residues).

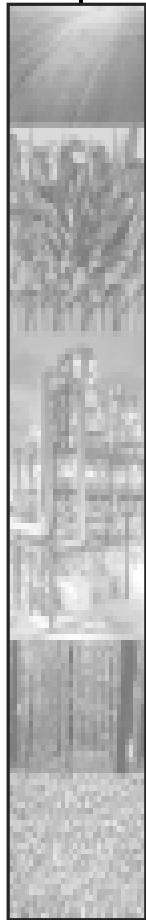




Introduction

Why is biomass so interesting?

1. Renewable resource available virtually anywhere
2. Considerable potential in the long term (residues and plantation in the long term)
3. Capacity to penetrate all energy market sectors (heating, power & transport) as well as the basic chemicals market
4. Important related advantages:
 - net CO₂-neutrality;
 - decrease noxious gas emissions (SO₂,etc.);
 - favour employment in rural areas;
 - contributes to the fight against desertification.





Biodiversity

Number of known species:

- Plants (multicellular organisms): > 248,420
- Algae: > 26,900
- Blue-green algae: > 4,760

- At present, only a very limited number of vegetal species are exploited (a few hundreds), mainly for food production.
- For a future **relevant bioenergy contribution**, a deep and worldwide research on **photosynthetic highly-efficient energy crops** is needed, especially regarding C-4 crops (because more productive).





Biodiversity

Examples of photosynthetic efficiency* :

(* *photosynthetic efficiency = crop energy content / solar radiation energy*)

Global terrestrial biomass efficiency (average):	0.05 %
Sugar cane – Sweet sorghum plantations:	2.5 %
Sugar beet plantations:	2.1 %
North Europe forestry:	0.07-0.26 %
Reeds:	1 %
Eucalyptus:	0.9-1.7 %
Maximum in laboratory experiments:	7 %
Maximum (few hours) sweet sorghum:	27 %

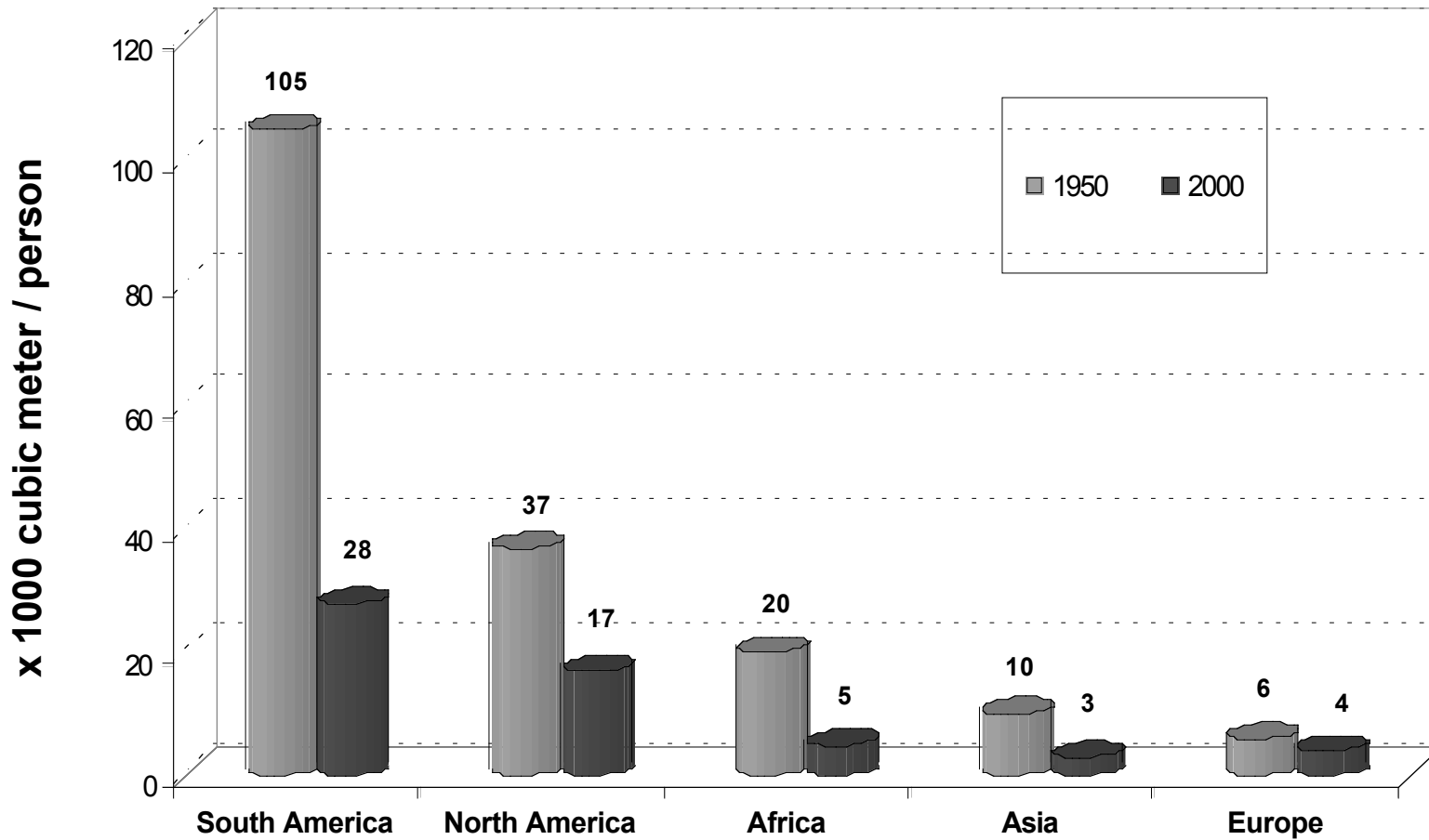
An increase of **1%** in photosynthetic efficiency
would provide **~100 MWh/ha.year**





Water resources on the globe

Water availability



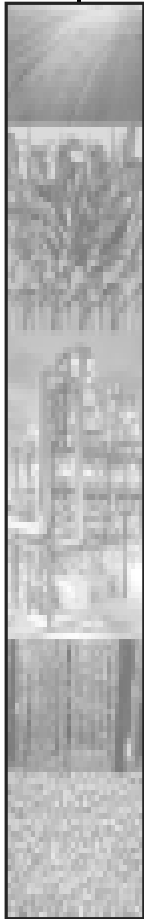


Worldwide conventional resources

(estimation)

- Accumulated underground during 500 million years -

- Sediments (total organic carbon content): 10^{16} t
- Coal: 10,000 billion t
- Kerogene 10^7 billion t of C
(insoluble organic material in sediments, origin of petroleum)
- Petroleum:
 - total estimated stock: 1,000 billion TOE
 - oil already removed: 120 billion TOE
 - recoverable amount (“P-50 reserves”): 116 billion TOE
- Current annual oil consumption: 4.8 billion TOE/y
(the amount accumulated during 2.3 million years)
- Present oil recovery level: ~ 50% total field stock
- Gas, peat, other dispersed carbon: 10^6 billion t of C





Worldwide biomass resources

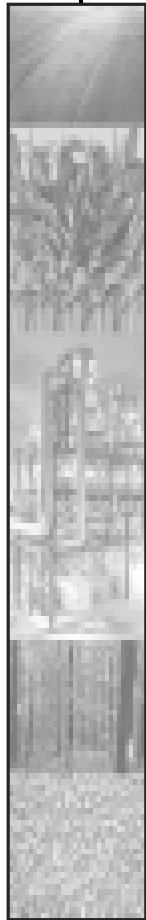


- **Worldwide biomass stock:** ~ 370 B TOE/a
- **World biomass production:**
 - Terrestrial: ~ 80 B TOE/a
 - Aquatic: ~ 20 B TOE/a
- **Estimation of biomass potential residues (2100):**
 - min: ~ 2,1 B TOE/a
 - med: ~ 6,6 B TOE/a
 - max: ~ 28,3 B TOE/a
- **Energy total consumption (2000):** ~ 9 625 B TOE/a

B TOE: Billion of Tonnes Oil Equivalent (1 TOE ~ 2,4 t dry biomass)



European biomass resources



- **Current consumption (EU-15; 2001):**
 - Primary energy: ~ 1486 M TOE/a
 - Biomass: ~ 57 M TOE/a
(3.8%)
- **EU guideline regarding biomass use:**
 - for 2010 ~ 135 M TOE/a
 - for 2020 ~ 200 M TOE/a
- **Biomass potential (2050)**
 - UE-15 ~ 500 M TOE/a
 - UE-25 ~ 600 M TOE/a

M TOE: Million of Tonnes Oil Equivalent (1 TOE ~ 2,4 t dry biomass)



To sum up

1

Depletion of fossil fuel resources :
~ 50% of recoverable petroleum already consumed

2

Biomass resources are abundant and available almost anywhere in the EU and worldwide, but with water constraints.

3

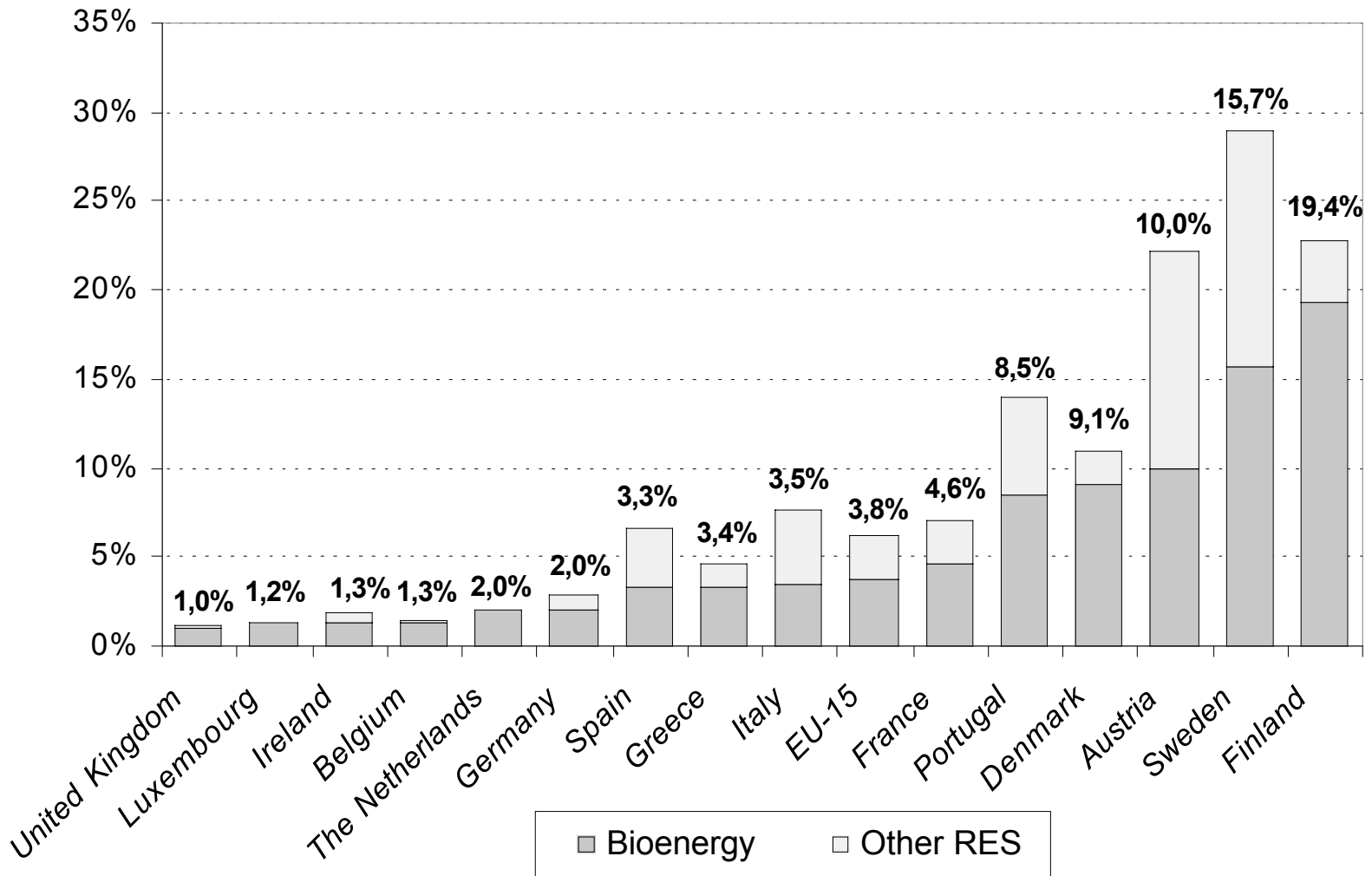
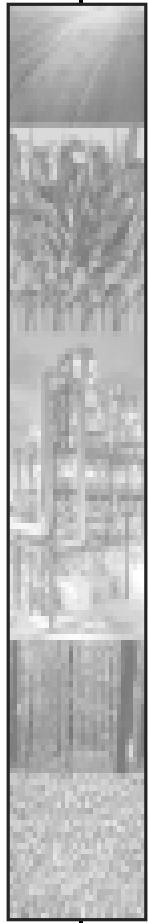
The main biomass contribution will likely be directed to :

- ➔ the strategic **transport sector**
- ➔ co-generation (**heat and power**)



Bioenergy in Europe

RES and Bioenergy shares on total Gross Inland Consumption
(EU -% - 2001; indicated percentages relate to bioenergy only)



Source: EUROSTAT



Bioenergy targets in Europe

Composition and objectives related to bioenergy in EU
(MTOE)

Biomass resource	1995	2000	White Paper goals for 2010
Solid biomass	42,9	48,4	102
Gaseous biomass	1,2	1,8	15
Liquid biofuels	0,4	0,9	18
<i>Biodiesel</i>	<i>0,28</i>	<i>0,70</i>	-
<i>Bioethanol</i>	<i>0,08</i>	<i>0,20</i>	-
Total	44,5	51,1	135

Source: Kopetz, 2003 in Renewable Energy in Europe (EREC) Draft copy January 2004



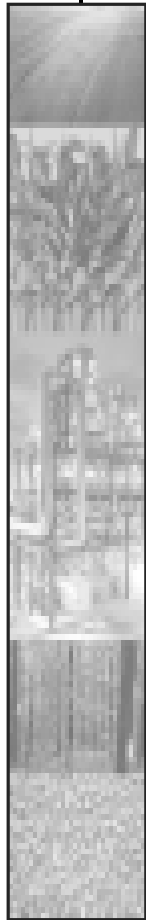
EU framework for biofuels

European directive 2003/30/CE (May 2003) :
promotion of the use of biofuels
and other renewable fuels for transport

Minimum proportion of biofuels and other
renewable fuels that should be placed on the
markets of each member state (in %*) :

By December 31 st 2005:	2 %
By December 31 st 2010:	5,75 %

**: calculated on the basis of energy content of all petrol and diesel for transport purposes placed on the markets at the corresponding date.*



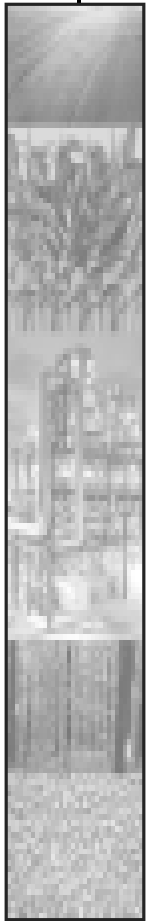


EU framework for biofuels

EU Directive 2003/30/CE :

Biofuels with the major technical and economic potential:

- Bioethanol (+ bio-ETBE)
- Biodiesel
- Biogas
- Biomethanol (+ bio-MTBE)
- Biodimethylether (DME)
- Synthetic biofuels
- Biohydrogen
- Pure vegetable oil





Overview of fuel properties



	Diesel engines				Otto engines				
	Diesel	Bio-diesel	DME	F-T diesel	Gasoline	Ethanol	ETBE	Methanol	MTBE
Chemical formula	$C_{12}H_{26}$	Methyl ester	CH_3O-CH_3	Paraffins	C_8H_{18}	C_2H_5-OH	$C_4H_9-OC_2H_5$	CH_3OH	$C_4H_9-OCH_3$
Cetane number	50	54	55-60	> 74	8	11	-	5	-
Octane number (MON)	-	-	-	-	86	92	105	92	100
Density (kg/l)	0.84	0.88	0.67	0.78	0.75	0.80	0.74	0.79	0.74
LHV (MJ/kg @ 15°C)	42.7	37.3	28.4	44.0	41.3	26.4	36.0	19.8	35.2
Stoich. air/fuel ratio (kg/kg)	14.5	12.3	9.0	-	14.7	9.0	-	6.5	-
Oxygen content (wt-%)	0-0.6	9.2-11.0	-	~ 0	-	-	-	-	-
Kinematic viscosity (mm²/s)	4	7.4	-	3.6	-	-	-	-	-
Flash point (°C)	77	91-135	-	72	-	-	-	-	-
Boiling temperature	-	-	-	-	30-190	78	72	65	55



Biofuels with the major technical and economic potential

- For each biofuel: **advantages** and **drawbacks** if compared between them or to other fuels
- The **economic aspect** will be the main driver of the penetration on the different energy market sectors
- Competitiveness will be based on the industrial costs of the end-products; an estimation for february 2004 (oil at 37 \$/bbl) is:

~ 350 - 450 €/TOE

(Variations according the country)



Best competitiveness levels (short term)

Bioethanol (*from sugar beets at 18 €/t*)

- Bioethanol azeotropic (96°): ~ **480** €/TOE
- Bioethanol dehydrated (100°): ~ **540** €/TOE

Biodiesel (*without support*)

~ **930** €/TOE

Biomethanol

- (*from biomass pellets (H₂) at 50 €/t*) ~ **480** €/TOE
- (*from natural gas at 3\$/MBTU*) ~ **360 - 290** €/TOE
- (*from coal – Lurgi process**) ~ **580** €/TOE

Biohydrogen

- (*from residues at 20 €/t; ~37%*) ~ **550** €/TOE
- (*from natural gas; ~63%*) ~ **290 - 500** €/TOE

Biodimethylether

~ **600** (?) €/TOE

Fischer-Tropsch

~ **700** (?) €/TOE

*: 404 €/TOE in 1981 increased 2%/year



Investments and production costs

	Specific investment [€/TOE biofuel.day] (20 years of operation)		Production costs [€/TOE]	
	Short term	Long term	Medium term	Long term
RME	291	213	630	252
Ethanol (sugar crops)	562	330	840	-
Ethanol (wood)	678 ?	350 ?	420	-
Methanol	1,357	1,027	462	294
DME	-	-	588	-
F-T diesel	1,395	970-1,040	462	-
Pyrolysis oil	1,938	1530	462	-
HTU diesel	1,037	775	252	-

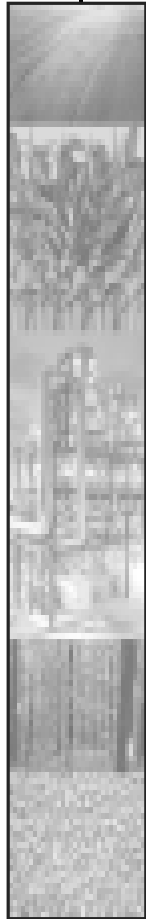
Source: ECN. van Thuijl et al. An overview of biofuels technologies, markets and policies in Europe. January 2003



Bioethanol: promising & competitive biofuel

Brasil

Crop:	sugar cane (308 mio t.cane/year)
Area:	~ 5 mio ha (potential: 33 mio ha)
Sugar yield (average):	7.5 t sugar/ha
Bioethanol yield:	~ 75 li/t cane
Residues (bagasse + waste):	$(0.14+0.14) = 0.28$ d.t/t cane
ETOH production:	~ 7 mio m³ hydrated/y, or ~ 7.5 mio m³ anhydrous/y
Sugar production:	~ 20 mio t/y
Bioethanol production cost:	~ 112 \$/m³ (140 \$/t) at the moment; ~ 15% reduction expected in the future
CO ₂ trade-off value:	5.9 \$/t CO₂
Bioethanol market value:	~ 2.5 billion \$ (12.5 mio m ³)
Flexible fuel car (able to use any mixture ETOH + gasoline)	Boom expected in the future





Bioethanol: promising & competitive biofuel

European Union

Bioethanol energy activity: very modest

Many countries (following E.C. directive) start to plan significant investments (in particular Germany)

Production cost of bioethanol from conventional crops (wheat, corn, sugar beets): approx. **400-500 €/t**

Estimated production cost of bioethanol from most promising crops (e.g. sweet sorghum): **approx. 250 €/t**

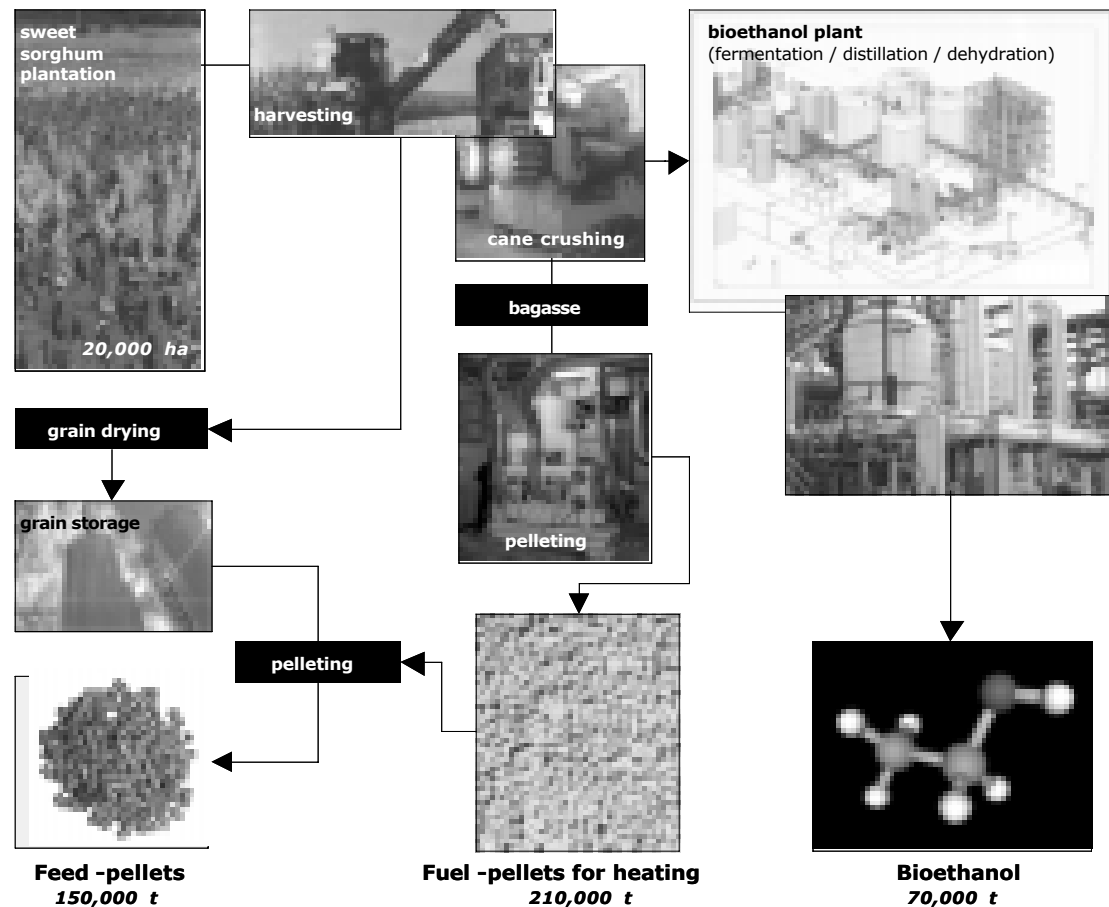
Market value:

- Europe: 590 €/t
- USA: 500 €/t



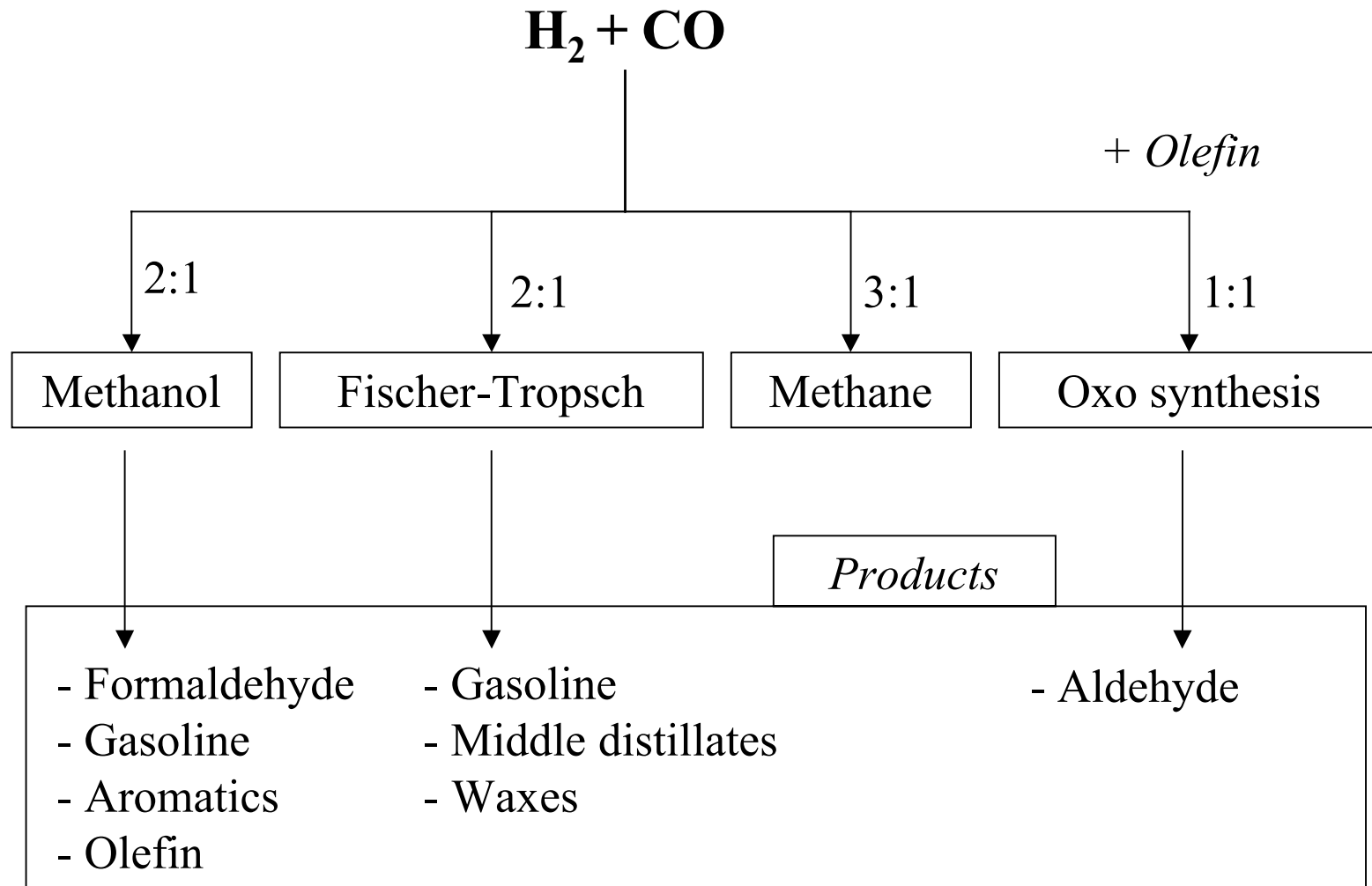
Integrated Bio-energy Complex

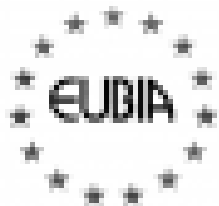
A With simultaneous production of animal feed and fuel pellets, bioethanol can be sold at **250 €/t**.





Synthesis gas routes





Agricultural set-aside in the EU

- **Total area**

- EU-15	3,234,295	km ²
- CC-10:	738,574	km ²
TOTAL	3,972,869	km²

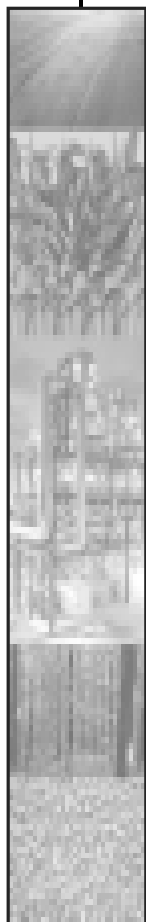
- **Total utilised agricultural area (UAA)**

- EU-15	131	million hectares
- CC-10:	36	million hectares
TOTAL	167	million hectares

- **Current set-aside area**

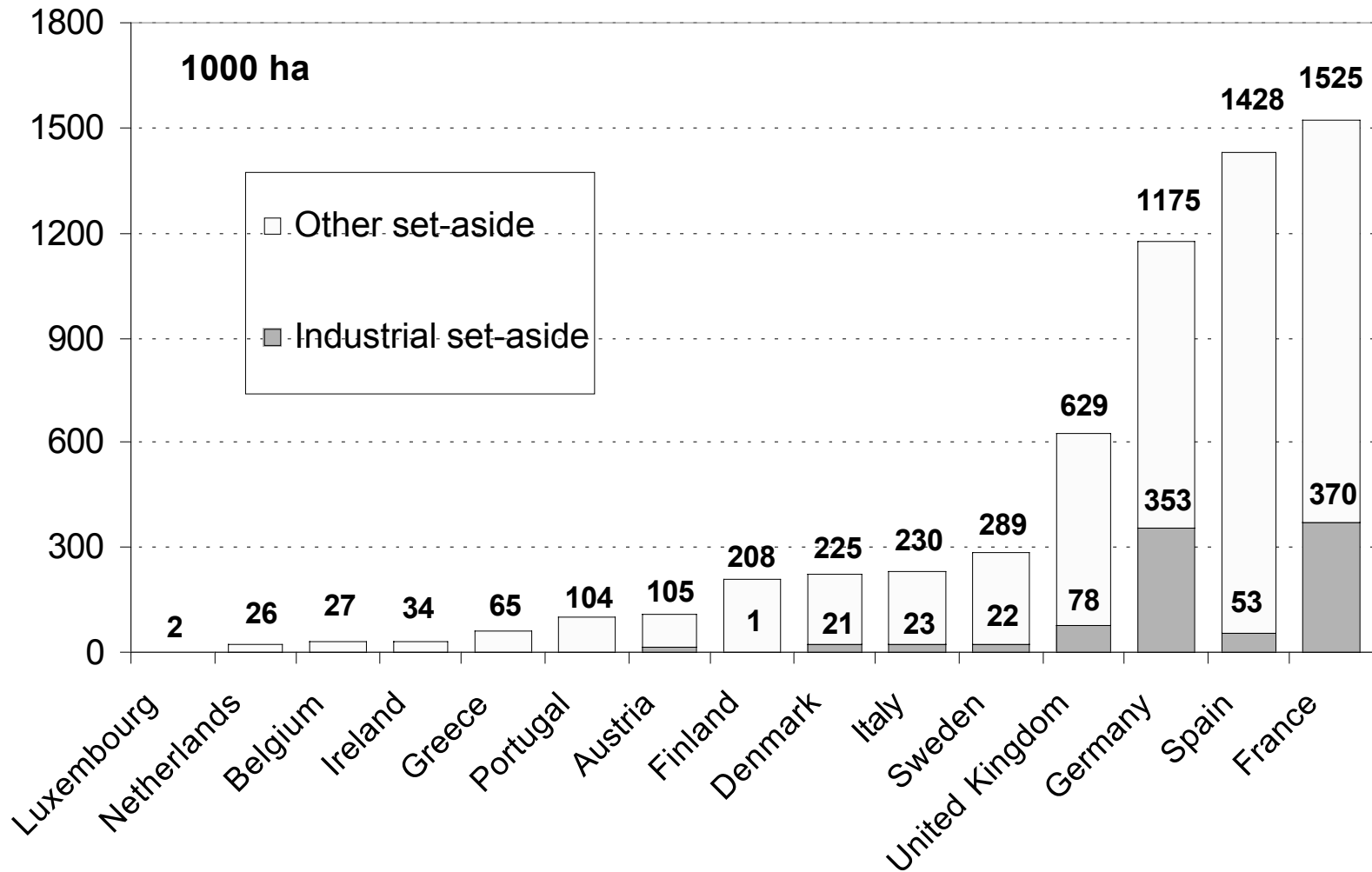
- EU-15	6	million hectares
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This corresponds to **4.7%** of the current EU-25 UAA





Agricultural set aside area in the EU-15



Source: European Commission, Directorate-General for Agriculture. (2002-2003)



European set-aside energy potential

6 million hectares

set-aside (UE-15 - 2002/2003)

→ Theoretic potential comprised between

6 - 23 MTOE

of biofuels

→ This corresponds to

1,9 – 7,4 %

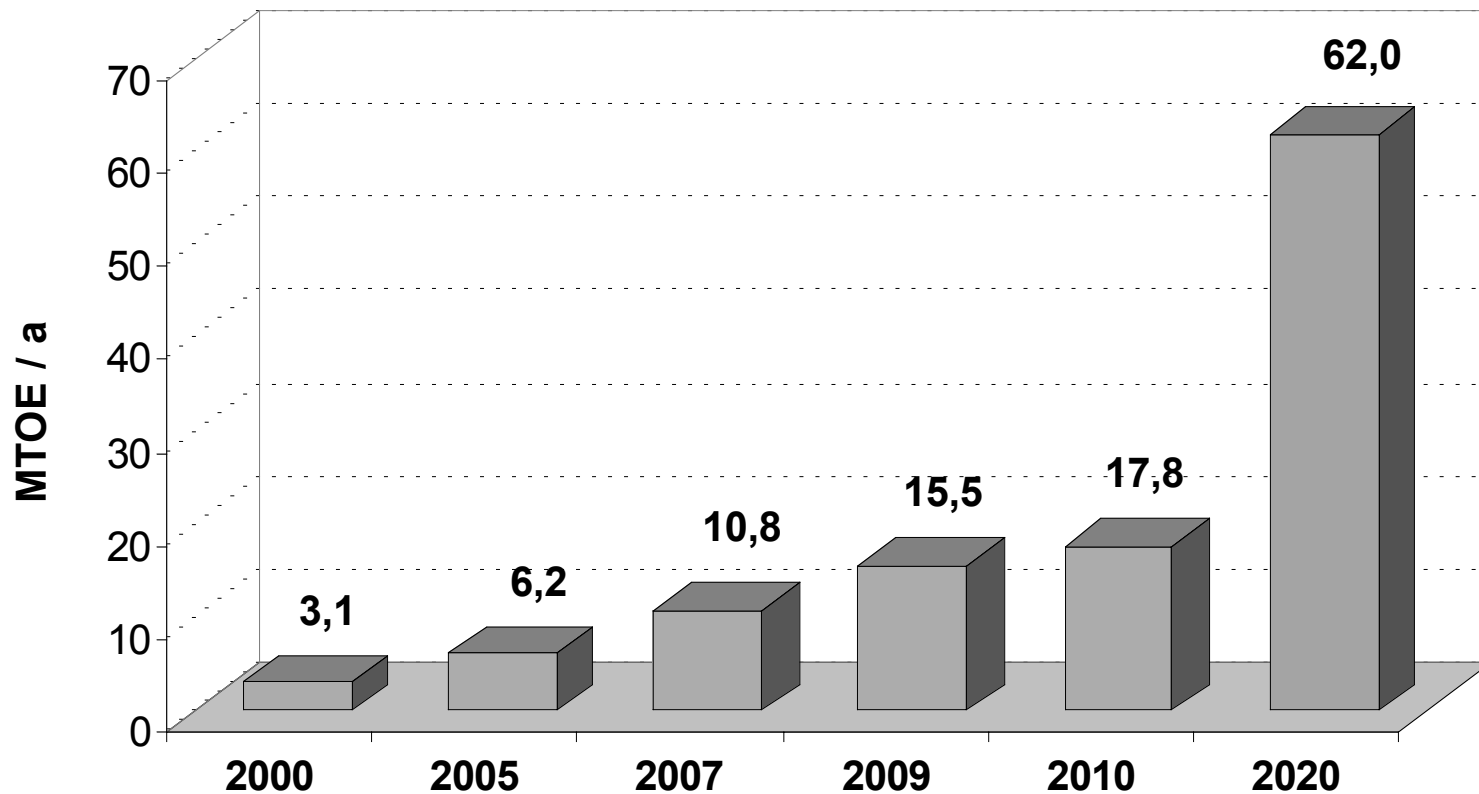
of the energy value of the biofuels used in the European transport sector (312 MTOE in 2001)



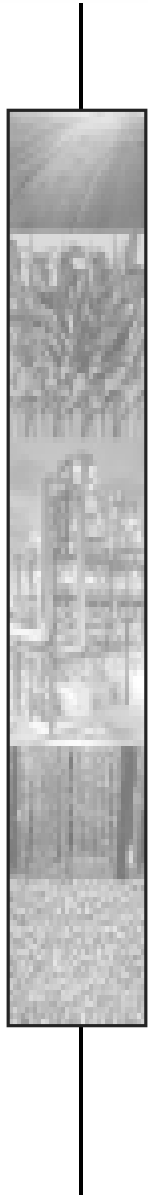


Potential evolution of biofuels and alternative fuels in Europe

Target evolution for biofuels and alternative fuels in the EU



Total consumption in the transport sector (2001):
312 M TOE / year





Estimation of agricultural land needed for the 2020 objective (if covered exclusively by biofuels)

- **Assumption on the distribution of the 62 MTOE (2020 target):**

- 80% bioethanol + biomethanol (i.e. 49.6 MTOE)
- 10% biodiesel (i.e. 6.2 MTOE)
- 10% biohydrogen (i.e. 6.2 MTOE)

- **Average yields for each biofuel:**

- Bioethanol + biomethanol : 4.30 TOE/ha
- Biodiesel: 1.35 TOE/ha
- Biohydrogen: 3.30 TOE/ha

- **Corresponding areas to be cultivated yearly:**

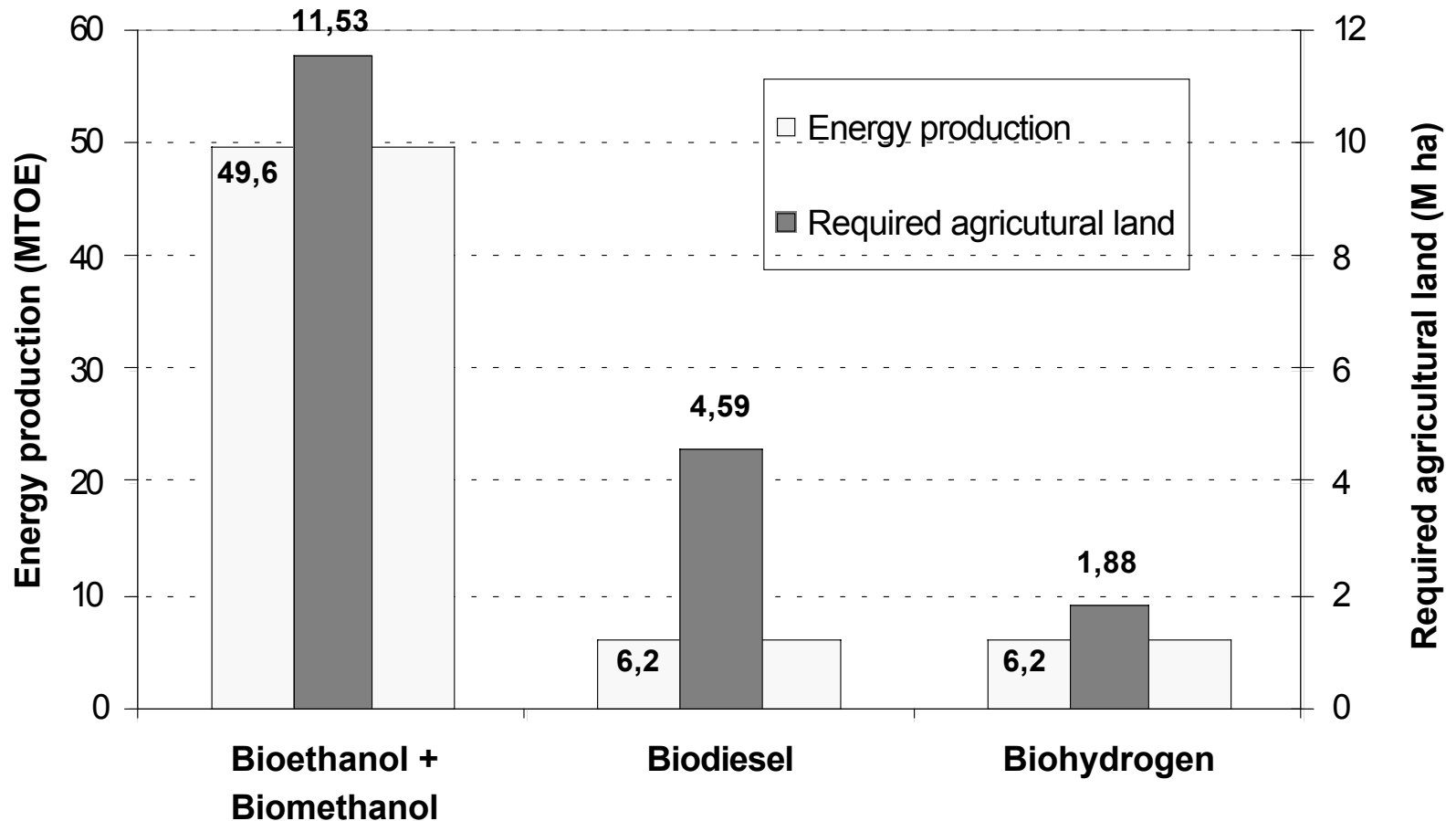
- For bioethanol + biomethanol : 11.53 M ha
- For biodiesel: 4.59 M ha
- For biohydrogen: 1.87 M ha

⇒ **Total agricultural area needed ~ 18 M ha/year**

This corresponds to approx. **11 %** of total UAA of UE-25 (~ 167 M ha)



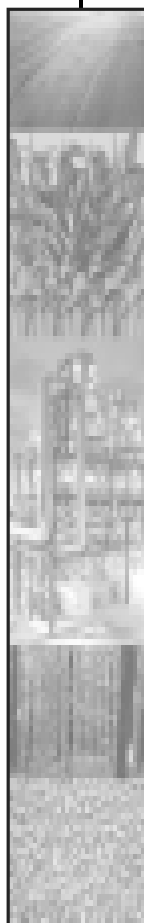
Estimation of agricultural land needed for the 2020 objective



∨ Total required area: **18 M ha** (11% of the UE-25 UAA)



Employment related to biofuels

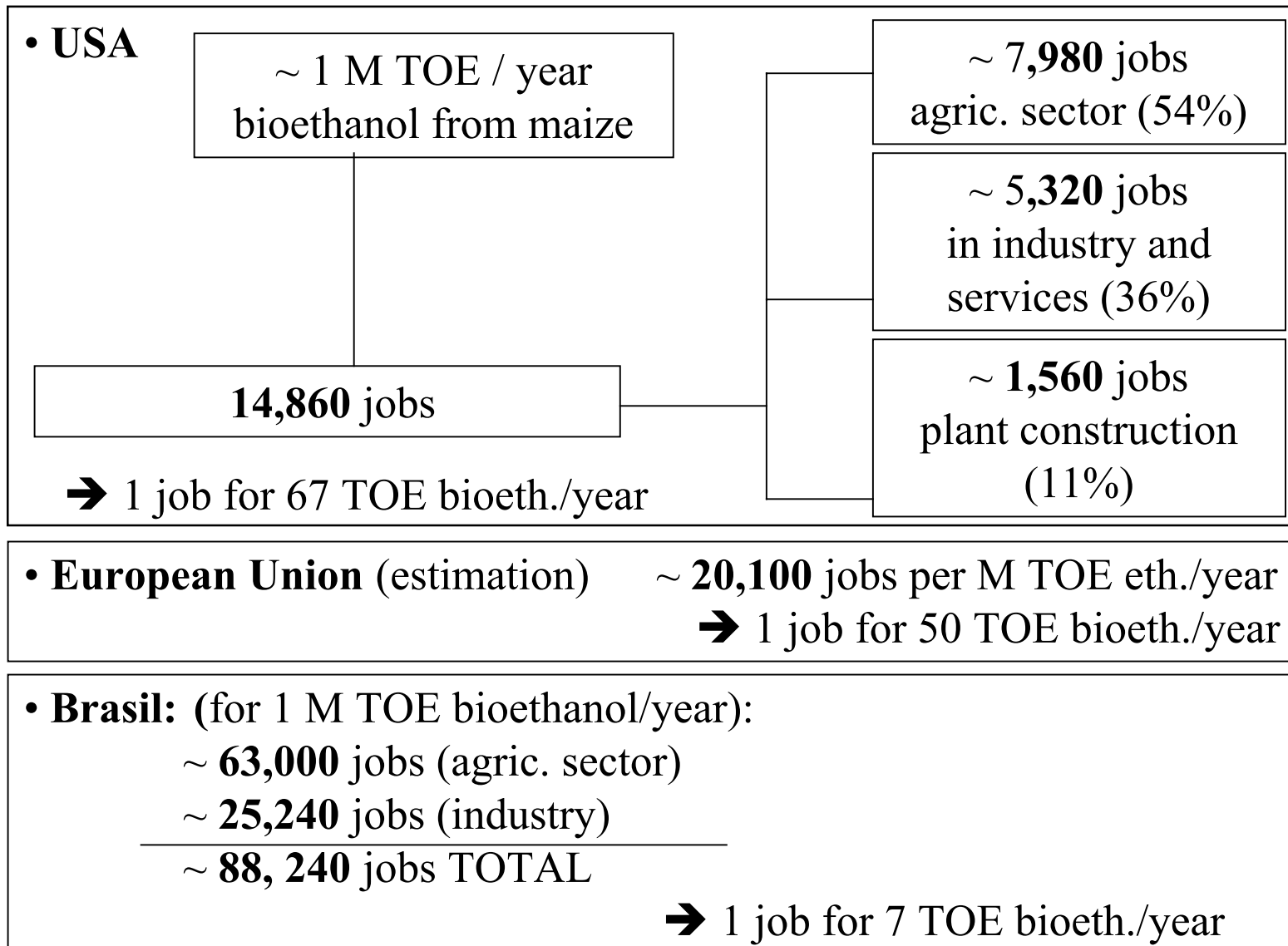


Biofuels		
<u>Solid:</u>		3,000-5,000 (prod. + transp. + handling)
<u>Liquid:</u>	Bioethanol	18,000-28,000
	Biomethanol	12,000-16,000
	Vegetable oil	29,000
<u>Bioelectricity</u>		1,650 (resource prod. + power gen.)
Natural gas		430
Crude oil		400 (on-shore extraction)
		450 (off-shore extraction)
		195+400 = 595 (refining+distribution)
Coal		925
Nuclear		235 (from mining to fuel manuf.)

(data for industrialised countries)



Employment related to bioethanol





Bioethanol: noxious emissions reduction

1 million m³
bioethanol

...reduces...

↘ 2,2 million
tonnes
CO₂

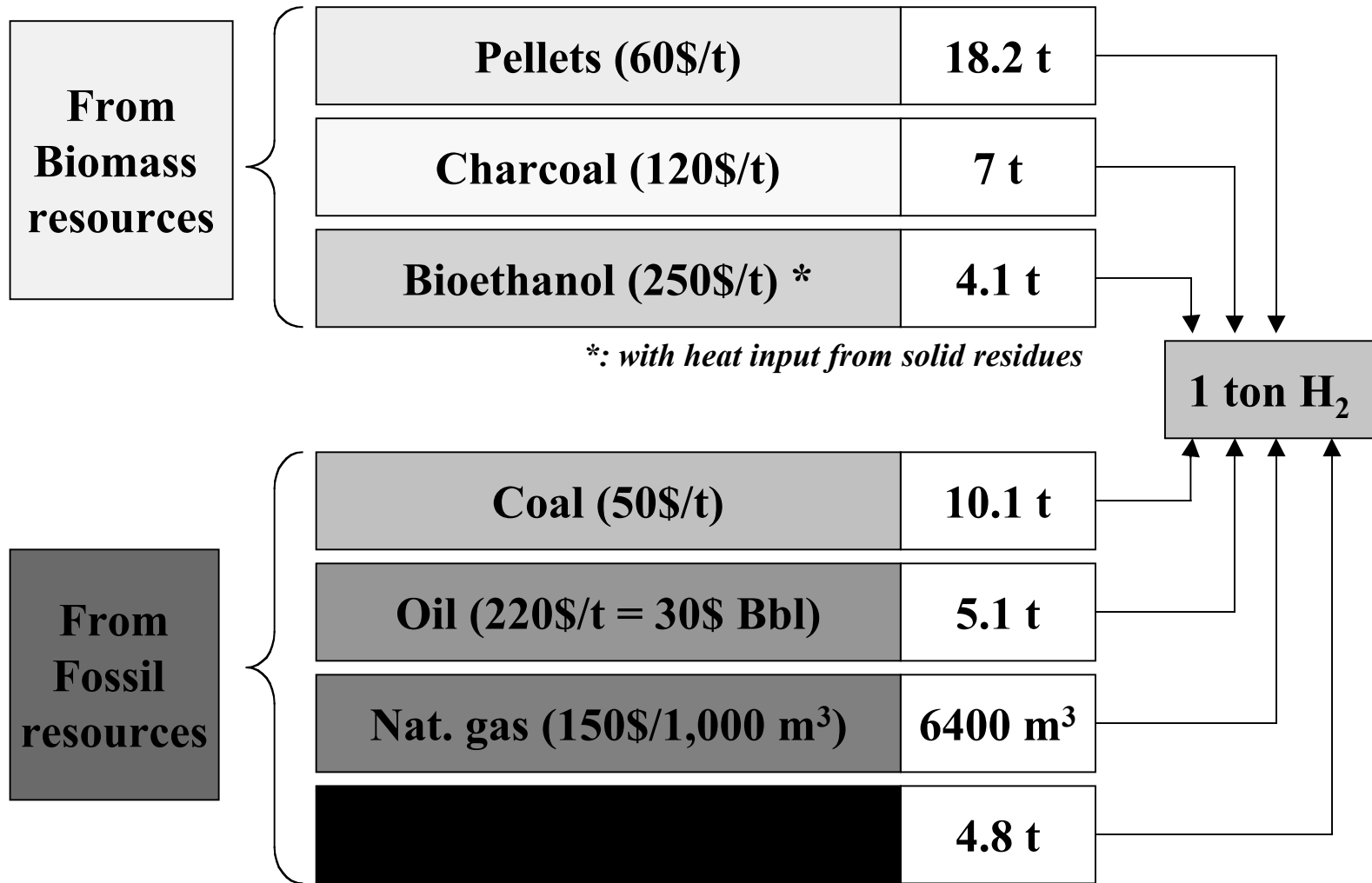
↘ 1,2
tonnes
SO₂

↘ 6,95
tonnes
NO_x





Two paths for biohydrogen production





Conclusion

- World-wide, the potential of biomass resources is very high and very promising.
- In particular, biofuels are expected to provide a considerable contribution to the transport sector (probably ~20% by 2020)





**Thank you
for your attention**

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