

General framework of European Initiatives for Biofuels

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Introduction

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
(+12 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 crops or agro-forestral residues).



Introduction

Why is biomass so interesting?

1. Renewable resource available virtually anywhere
2. Considerable potential 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:
 - decrease noxious gas emissions (CO_2 , SO_2);
 - 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.



Biodiversity

Examples of photosynthetic efficiency* :

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

Global terrestrial biomass efficiency:	0.11 %
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:	17 %

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



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
(i.e. 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

Biomass resources are **abundant** and **available** almost anywhere in the EU and worldwide

2

The main biomass contribution will likely be directed to :

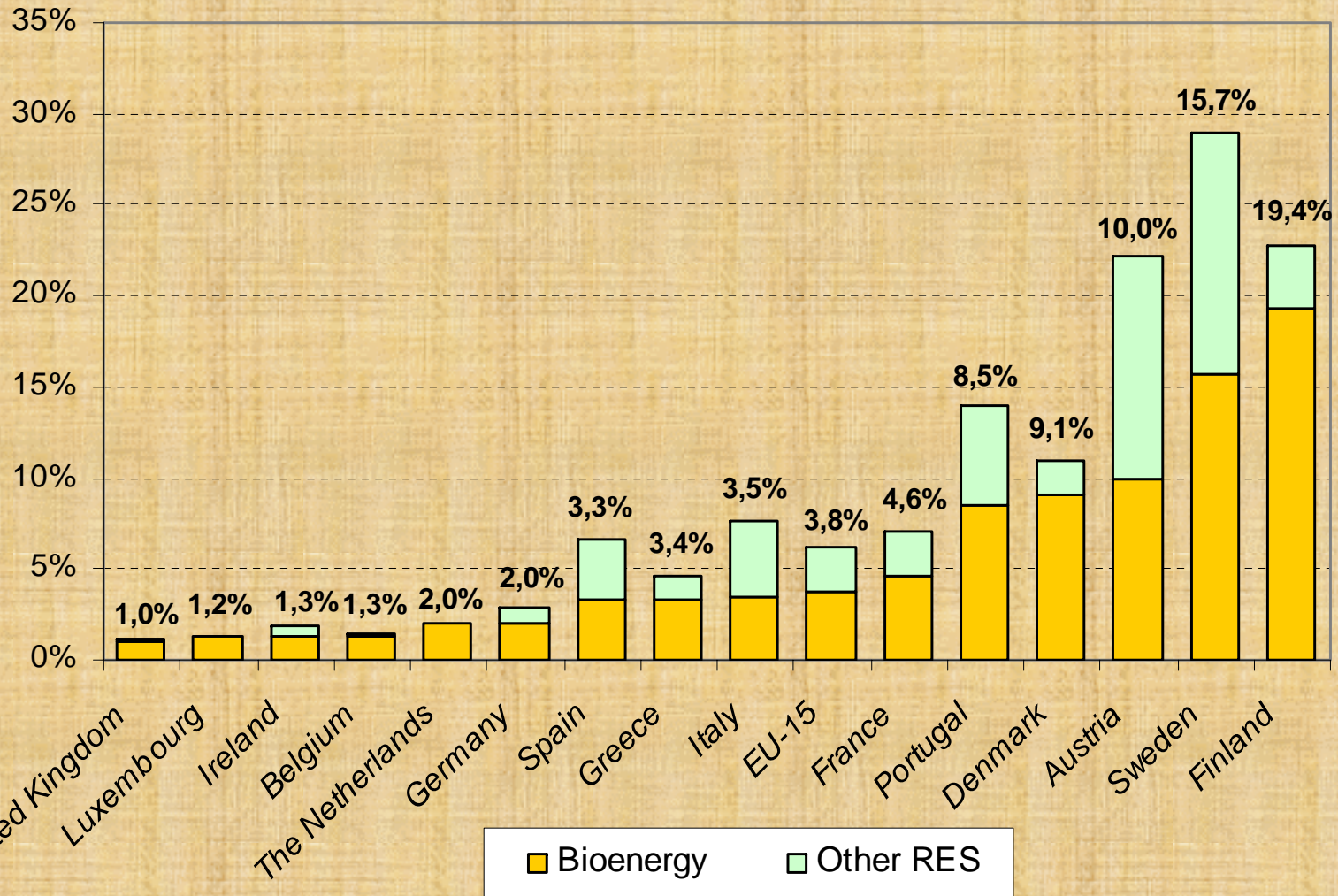
- ➔ the strategic transport sector
- ➔ co-generation (heat and power)



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 - 2003)

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 31st 2005: 2 %

By December 31st 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

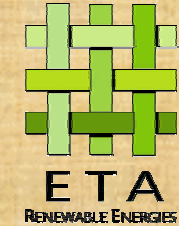
EU Directive 2003/30/CE :

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	$C_{12}H_6$	Methyl ester	CH_3O-CH_3	Paraf-fins	C_8H_{15}	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 (mm ² /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 is:

~ 350 - 450 €/TOE

(Variations according the country)



Best competitiveness levels



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**

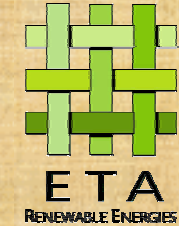
Biohydrogen

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

Biodimethylether ~ **600 (?) €/TOE**

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

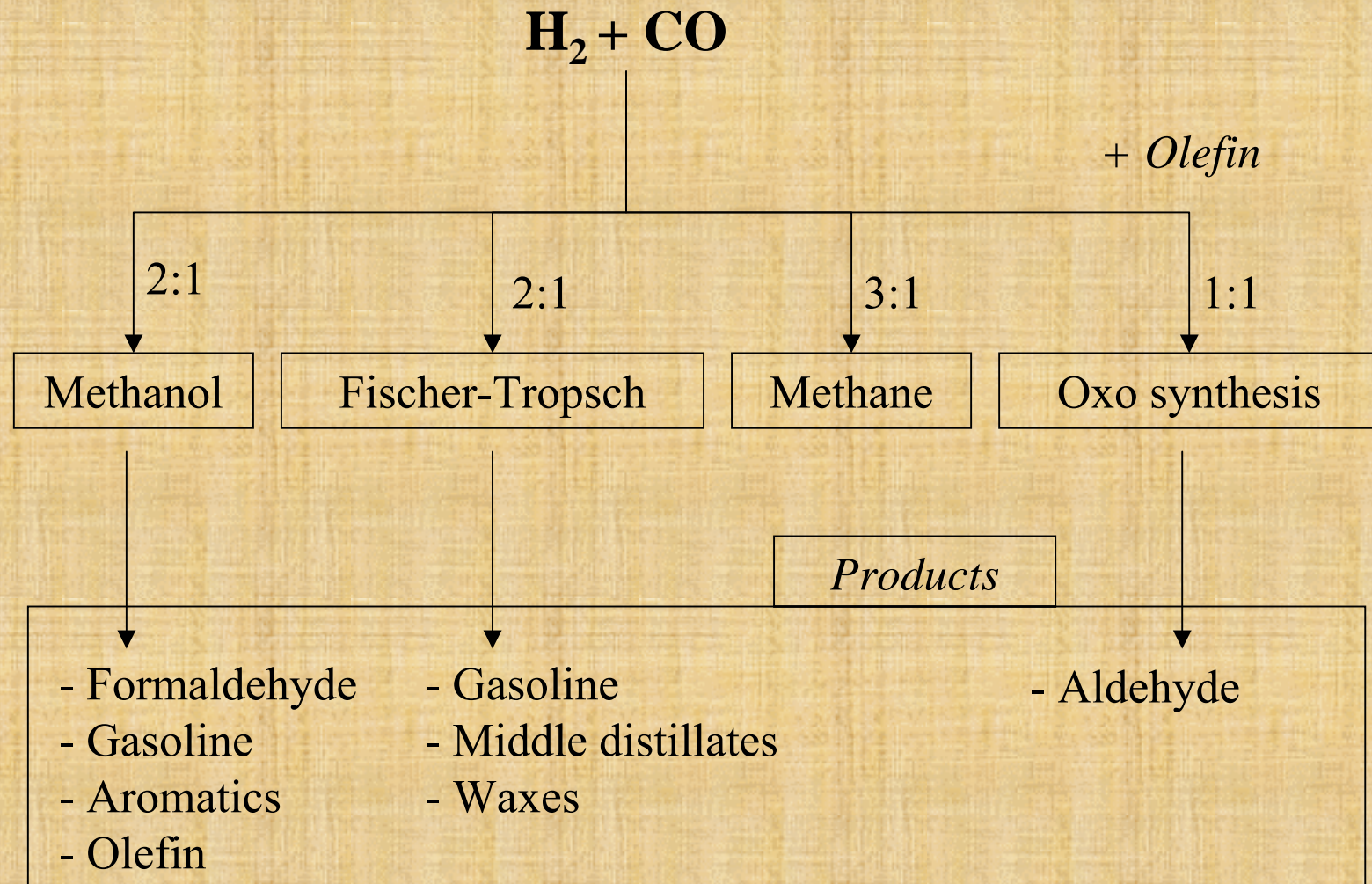
Investments and production costs



	Specific investment [€/TOE biofuel.day] (20 years of operation)		Production costs [€/TOE]	
	Short term	Long term	Short 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	1,530	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

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

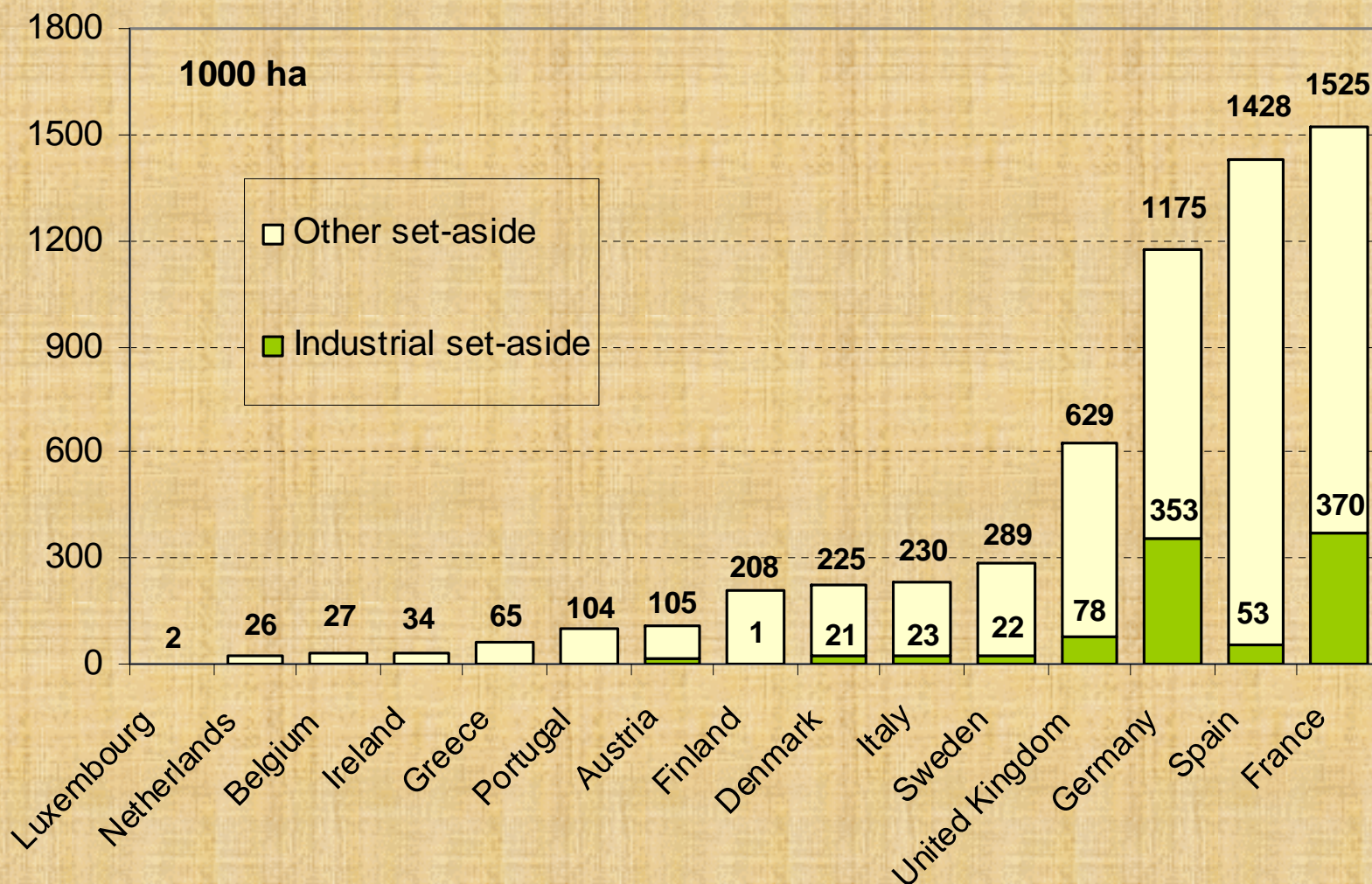
• Current set-aside area

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

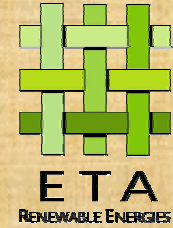


Agricultural set aside area in the EU-15



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

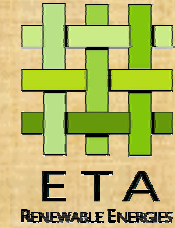
→ This corresponds to

1,9 – 7,4 %

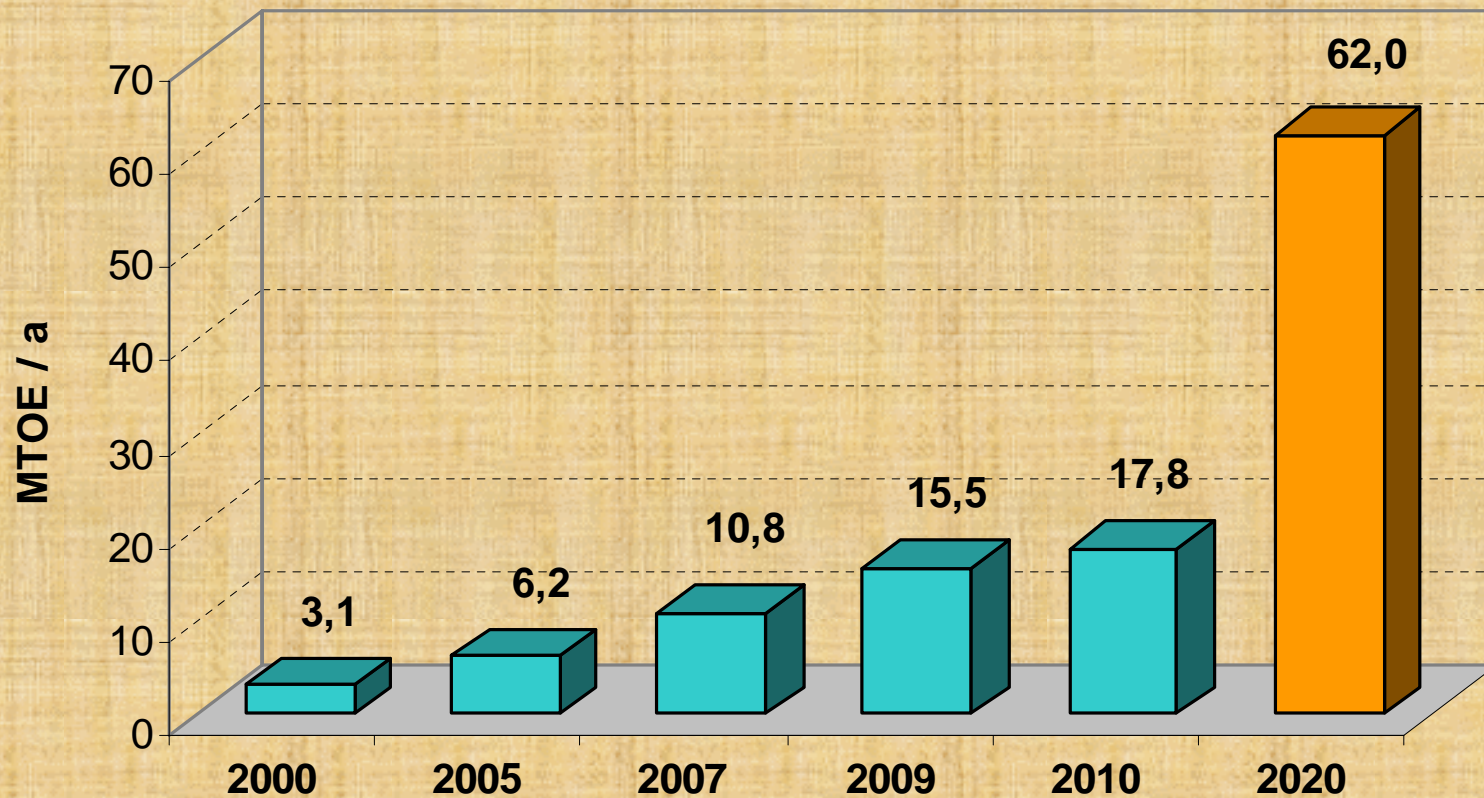
of the energy value of the biofuels used in the European transport sector (312 MTOE in 2001)



Potential evolution of biofuels in Europe



Target evolution for biofuels in the EU



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



Estimation of agricultural land needed for the 2020 objective



- **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:**

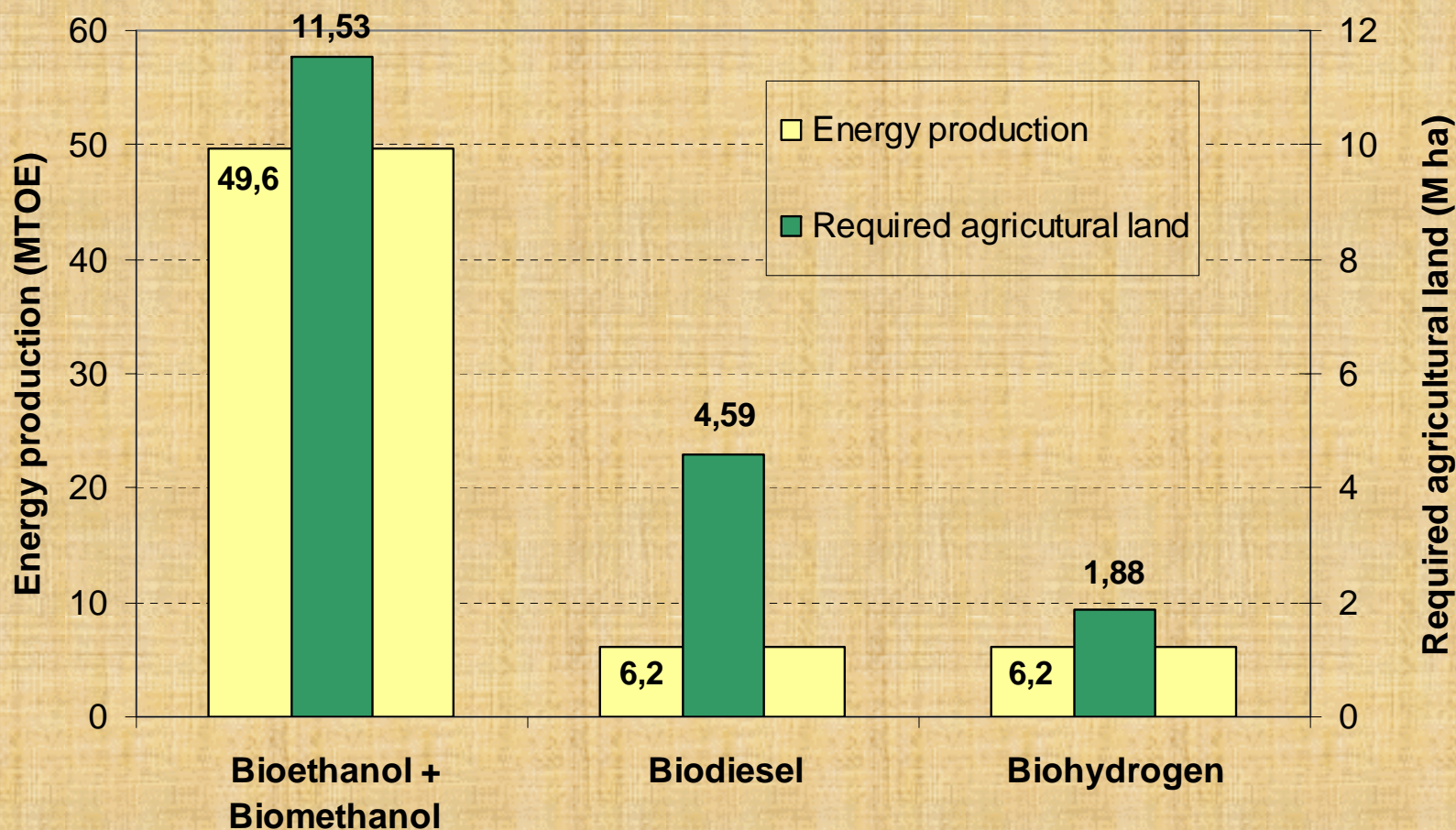
- For bioethanol + biomethanol : 11.53 M ha
- For biodiesel: 4.59 M ha
- For biohydrogen: 1.87 M ha

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

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



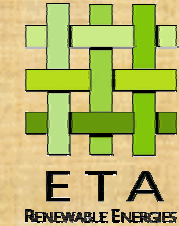
Estimation of agricultural land needed for the 2020 objective



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



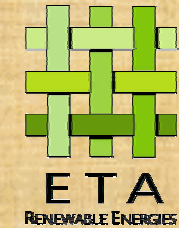
Employment related to biofuels



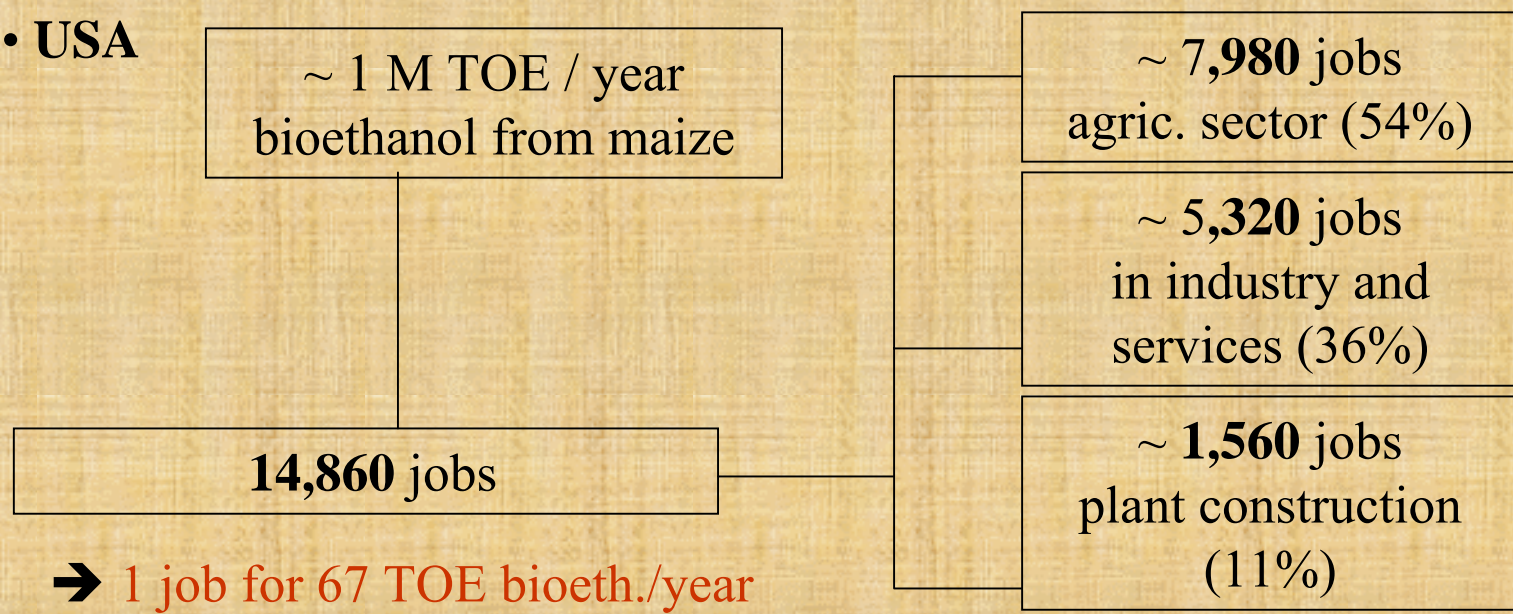
Sector	Nr. of direct jobs/MTOE produced per year	
Biofuels		
<u>Solid:</u>	3,000-5,000	(prod. + transp. + handling)
<u>Liquid:</u>	Bioethanol	18,000-28,000
	Biomethanol	12,000-16,000
	Vegetable oil	29,000
		(resource prod. + process)
<u>Bioelectricity</u>	1,650	(resource prod. + power gen.)
Natural gas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

(data for industrialised countries)

Employment related to bioethanol



• USA



• **European Union** (estimation) ~ 20,100 jobs per M TOE eth./year
→ 1 job for 50 TOE bioeth./year

• **Brasil:** (for 1 M TOE bioethanol/year):

~ 63,000 jobs (agric. sector)

~ 25,240 jobs (industry)

~ 88, 240 jobs TOTAL

→ 1 job for 7 TOE bioeth./year

Bioethanol: noxious emissions reduction

1 million m³
bioethanol

...reduces...

↘ 2,2 million
tonnes
CO₂

↘ 1,2
tonnes
SO₂

↘ 6,95
tonnes
NO_x



2 paths for biohydrogen production



From Biomass resources

Pellets (60\$/t)	18.2 t
Charcoal (120\$/t)	7 t
Bioethanol (250\$/t) *	4.1 t

**: with heat input from solid residues*

From Fossil resources

Coal (50\$/t)	10.1 t
Oil (220\$/t = 30\$ Bbl)	5.1 t
Nat. gas (150\$/1,000 m³)	6400 m³
Nafta (250\$/t)	4.8 t

1 ton H₂

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**

