European Biomass Industry Association

Bioenergy for the future

Point of view of EUBIA

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11 April 2006
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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

Why is biomass so interesting?

- Renewable resource available virtually anywhere
- Considerable potential in the long term (residues and plantation in the long term)
- Capacity to penetrate all energy market sectors (heating, power & transport) as well as the basic chemicals market
- Important related advantages:
  - net CO_2-neutrality;
  - decrease noxious gas emissions (SO_2,etc.);
  - favour employment in rural areas;
  - contributes to the fight against desertification.

Worldwide biomass resources

- **Worldwide biomass stock**: ~ 370 B TOE/y

- **World biomass production**:
  - Terrestrial: ~ 80 B TOE/y
  - Acquatic: ~ 20 B TOE/y

- **Estimation of world biomass residues potential** (year 2100):
  - Biomass residues potential: ~ 6.6 B TOE/y
  - Ultimate future potential (max): ~ 28.3 B TOE/y

- **Total Energy consumption** (2000): ~ 9.9 B TOE/a

- Total nuclear energy supply in year 2000: 638 MTOE/y
  2020: 690 MTOE/y

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

Estimation of world future role of bioenergy

Projections of future potential	Contribution (M Toe / year)*	
Oranisation	**2025**(year)	**2050**(year)
Shell (1996)	2,030*	4,750*
IPCC(1996)	1,720	6,700
Greenpeace(1993)	2,720	4,320
Johansson et al. (1993)	3,470	4,920
WEC (1993)	1,400	3,000
Dessus et al. (1992)	3,220	-
Lashof and Tirpak (1991)	3,100	5,130
Fisher and Schrttenholzer (2001)	8,350	10,750
Average	**3,250**	**5,650**

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	%

Biodiversity

In nature there is a wide variability as far as concerns the photosynthetic activity of plants:

- An increase of **1%** in photosynthetic efficiency of one specific crop would provide **~100 MWh/ha.year**
- Most of present biomass crops are food crops or wood industry crops. Only about 1000 species of the total 240,000 so far identified are well known, utilised and developed.
- Genome sequencing of promising crops of global interest (like sweet sorghum) could have large impact
- Discovery of the full photosyntetic mechanism could have considerable impact on the biomass resources availability and quality.

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

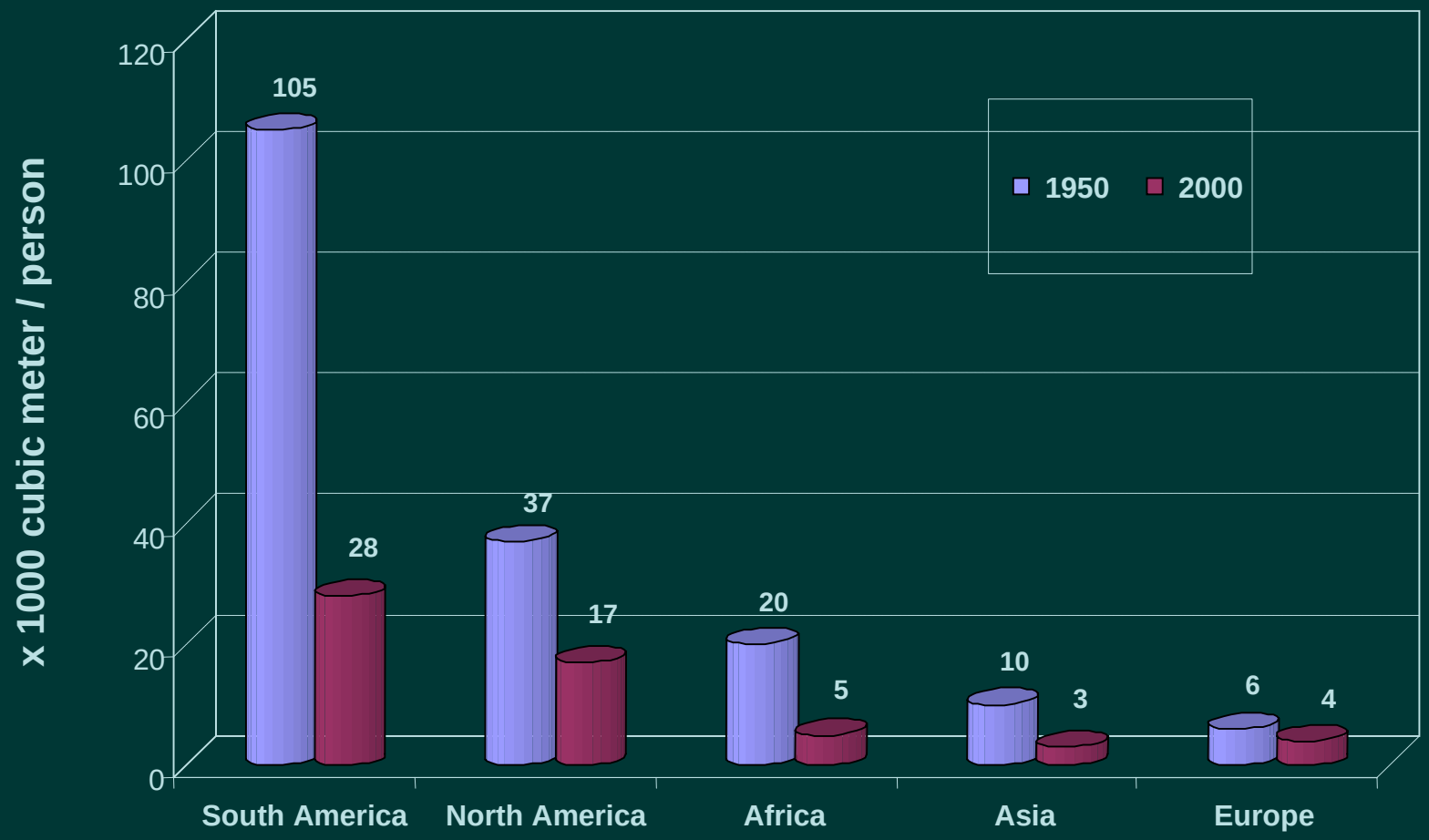
- **Biomass potential** (2050)

- 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)

Water resources on the globe

Water availability is an important constraint:
(1kg of dry biomass requires 200-1,000 kg of water!)



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

Which markets for biomass resources?

- 2.1 Heat and Cool production
- 2.2 Power production
- 2.3 Biofuels production for transport
- 2.4 Industrial commodities

Heat and Cool production

- **Solid biomass**

- Chips: local markets
- Briquettes: local markets
- Pellets: most economic and suitable biofuel for heat / cool production*

- **Liquid biofuels**

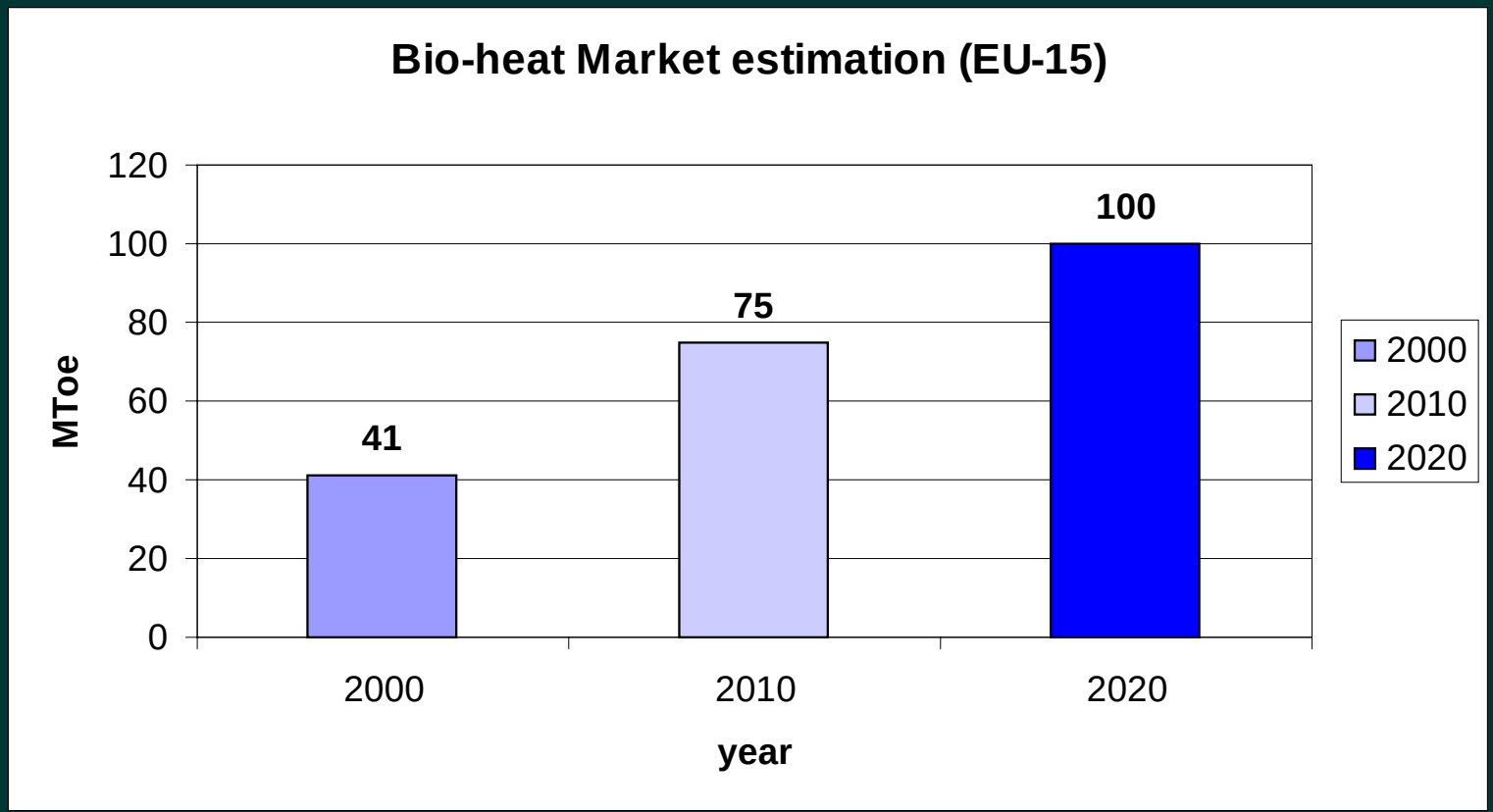
- Biodiesel: good biofuel but expensive
- Biocrudeoil: expensive and problems of stability

- **Gasous biofuels**

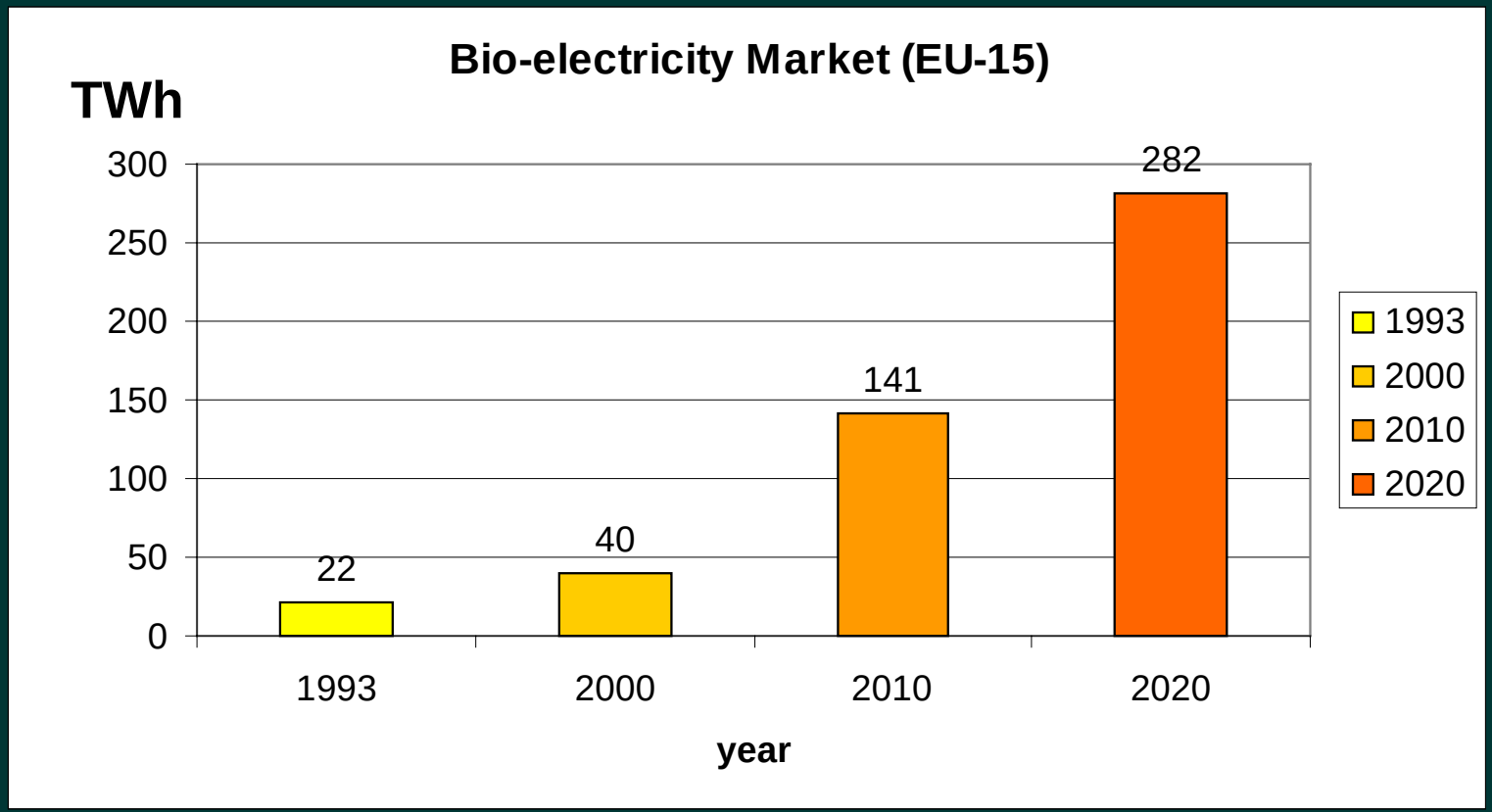
- Low Heating Value: low quality biofuel
- Medium H.V. : expensive
- Biogas : good properties and reasonable cost

* the use of pellets is already competitive in most of countries in comparison to conventional fuels, even in comparison to Natural gas (spot market price 10$/MM Btu)

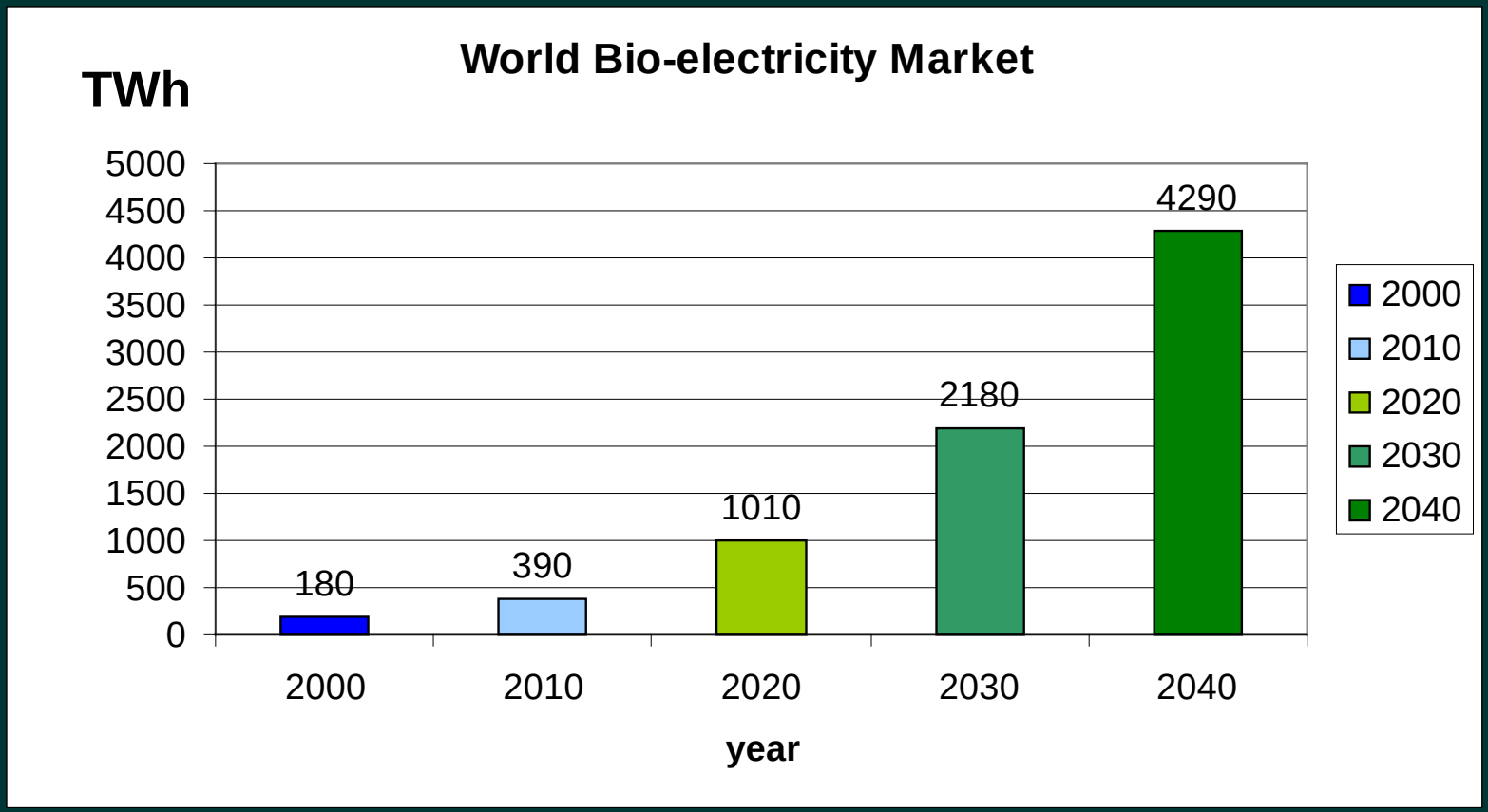
Sectorial markets



Sectorial markets



Sectorial markets



World-wide Co production of “Green-Power” & Bioethanol (from sugar cane/sweet sorghum)could have large impact on Development and G.H.G mitigation

Power production

- **Small power generators (few kWe to 1MWe)**

  - Small engines or micro gas turbines fuelled by biodiesel or bioethanol are today commercially available but with the following constraints:

    - **Limited timelife operation**
    - **Use of expensive biofuels**

  - Small power generators using solid biomass are not commercially available on the world markets even if the potential market is hudge (actual business of conventional generators is ~ 50 billions $ / year)

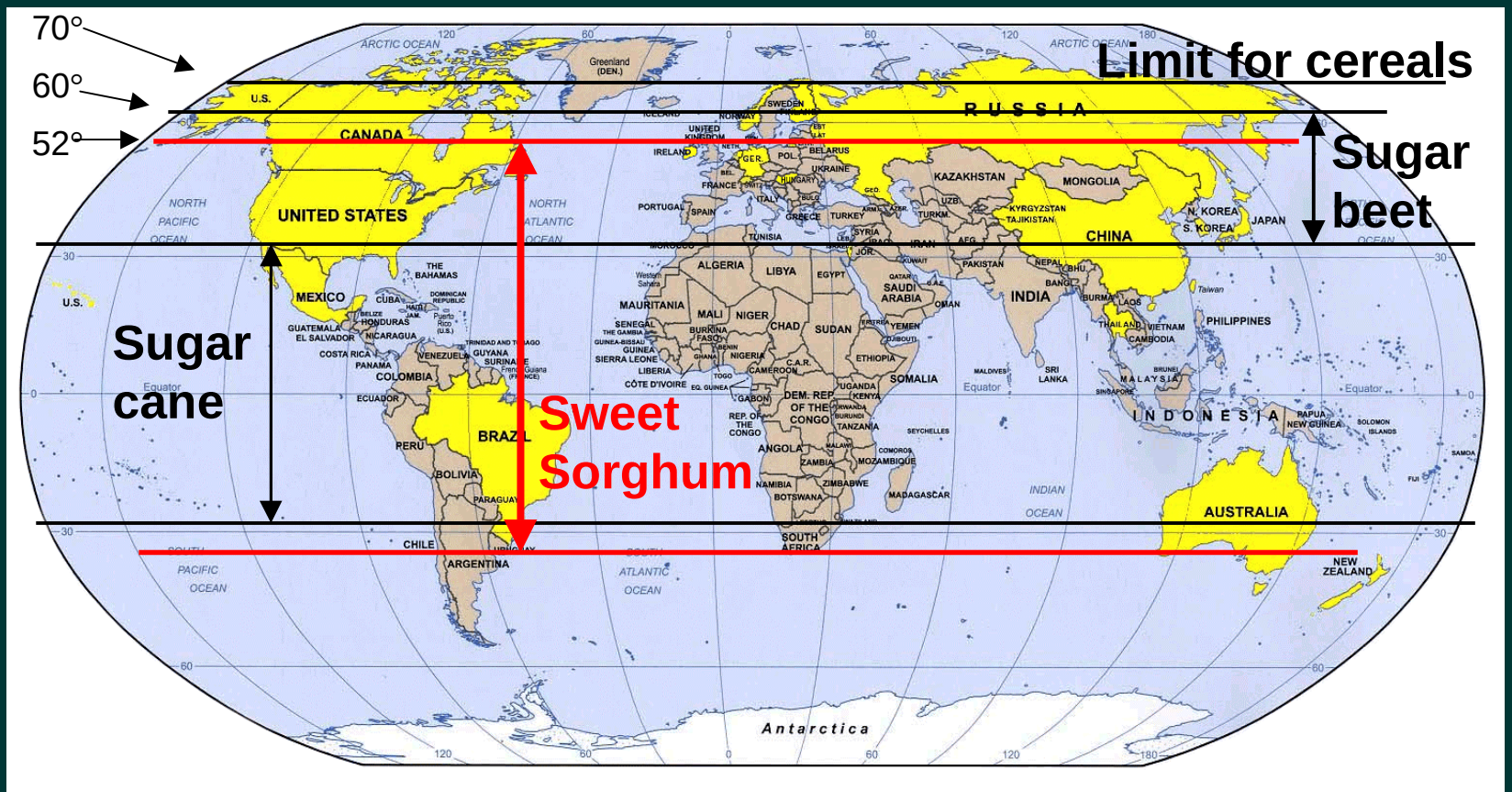
- **Large power generators (2 MWe to 500MWe)**

  - Solid biomass generator (steam condensing); capacity near to some tens of Mwe; ηel ~ 29%; specific investment ~ 2,000 € / Kwe

  - Liquid biomass advanced C.C. power generators;capacity: 50-500 Mwe ; ηel ~ 50-57%; specific investment ~ 600-500 € / Kwe; very low NO_x,SO_2 emissions. Very performant green power generators but using expensive bofuels !

Potential geographical areas for S. Sorghum

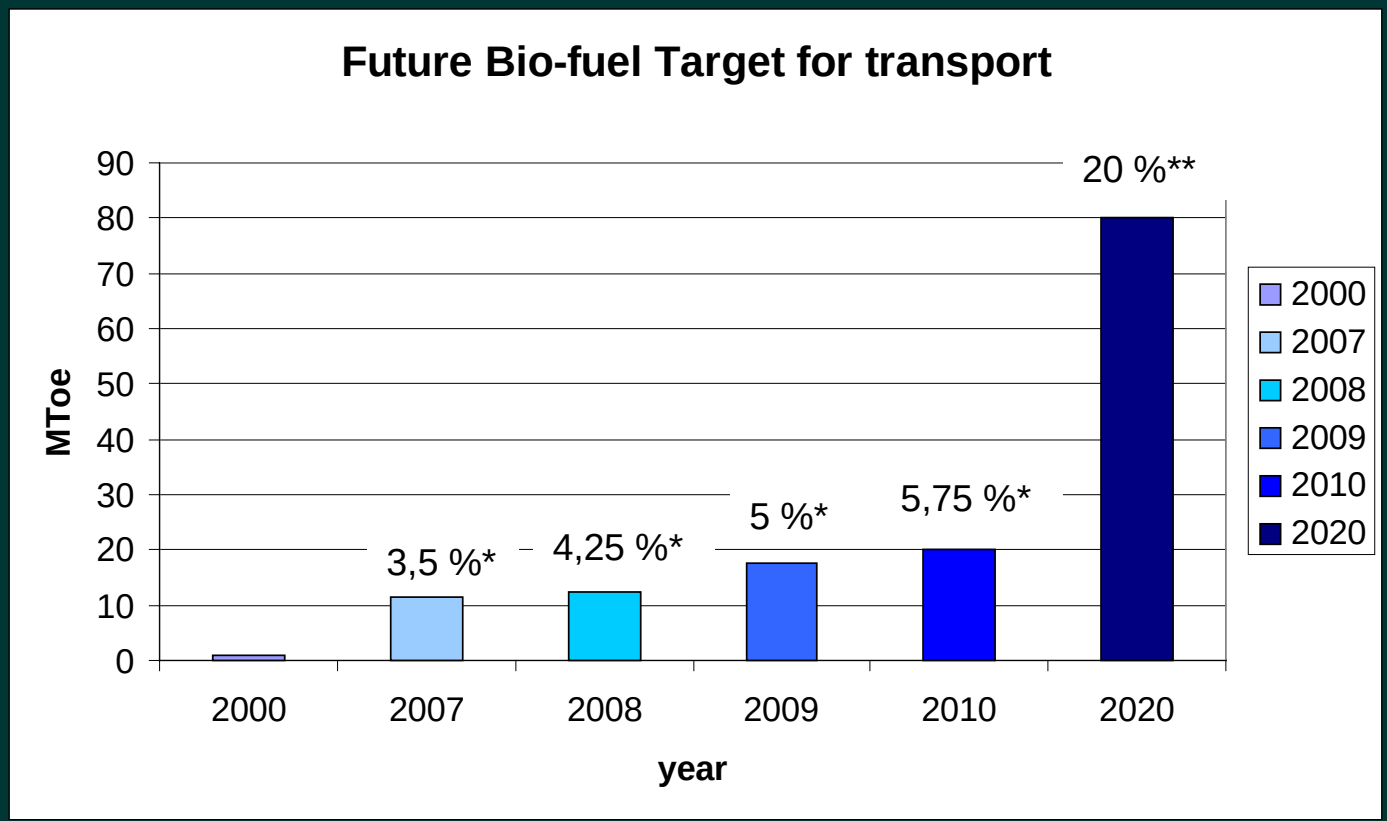
Because of his wide geographical cultivation potential Sweet Sorghum could be the most important energy crop for combined power&biofuel production



Sectorial markets EU directive 2003/30/CE (May 2003)

Total fuel for road-transport (2000): 310 MToe/y

* Bio-fuel target ratio on total fuel road-transport
** Proposal under discussion



Estimation of agricultural land needed for the 2020 objective EU (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)

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

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 market

- Competitiveness will be based on the industrial costs of the end-products (gasoline and diesel fuel); an estimation for september 2005 (oil at 60 $/bbl) is:

~ 450 €/TOE

Best competitiveness levels for biofuels

(short term)

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

- Bioethanol dehydrated (100°): ~ **740** €/TOE

Biodiesel *(without support)* ~ **930** €/TOE

Biomethanol ~ **600** €/TOE

Biohydrogen

- *from low-quality biom. pellets (90 € / t; ?~38%)* ~ **600** €/TOE
  (possible benefit from CO2 trading ~ **300** €/t H_2 *)*
- *H2 from natural gas at 10 $/MMBTU ; ?~57%* ~ **650** €/TOE

Fischer-Tropsch ~ **900-1000** €/TOE

Present Competitiveness of Commercial Biomass Energy Resources

Hydrocarbons Quotation

Crude Oil	61 $/bbl	10,000 Kcal/Kg
Natural Gas	44 $/bbleq	12,700 Kcal/Kg
Gasoil	74 $/bbleq	10,200 Kcal/Kg
Gasoline*	74 $/bbleq	10,500 Kcal/Kg
Methanol	74 $/bbleq	4,750 Kcal/Kg

Biofuels

Biomass (av. sale value 50$/dry ton)	20$/bbleq	4,100 Kcal/Kg
Pelletised Biomass	38$/bbleq	3,500 Kcal/Kg
Bioethanol (Brasil) (EU 117 $/bbleq; with Sweet Sorghum 59 $/bbleq)	28$/bbleq	7,000 Kcal/Kg
Bio-Methanol (combined with bioethanol production by commercial technology)	47 $/bbleq	5,500 Kcal/Kg
Bio-Hydrogen (small adaptation of commercial technology)	100 $/bbleq	30,000 Kcal/Kg

•The industrial cost of gasoline in the E.U. is 0,45 $/litre

One bbl (oil) = 157 litres = 0.135 T.O.E.

Bioethanol Competitiveness World-wide Comparison

Among possible short-term biofuels bioethanol is the most performing

- **EU** has a large feedstock potential but is the less competitive on the international market without subsidies with an average production cost of hydrous bioethanol **~ 500 €/t**;
- The **USA** has large feedstock potential and better competitiveness level with an average production cost of hydrous bioethanol (from corn) **~ 300 €/t**;
- **Brazil** has an enormous potential for expanding the sugar-cane growing area (from 5 mio ha → 33 mio ha) and it has the most competitive production cost with an average level of **~ 120 €/t**;
- **China** has now a limited potential but it could increase considerably if a partial substitution of sweet-sorghum to corn (i.e. 1/3 of the cultivated area) could be feasible (+40 mio m^3/year). The actual production cost (from corn) is **~ 400 €/t**. In the **south of China** from cassava should be much lower at **~ 260 €/t**;
- **South-East Asia** has a reasonable potential and a reasonable production cost of about **220 €/t** (hydrous bioethanol from cassava);
- **Australia** has a production cost of hydrous bioethanol from sugar-cane similar to USA level **~ 280 €/t**.
- In longer term bioethanol may be obtained from ligno-cellulosic resources (or from MSW, sludges,wastes) but will have to compete, for economic reasons, with other synthethic biofuels

Bioethanol: promising & competitive biofuel

European Union

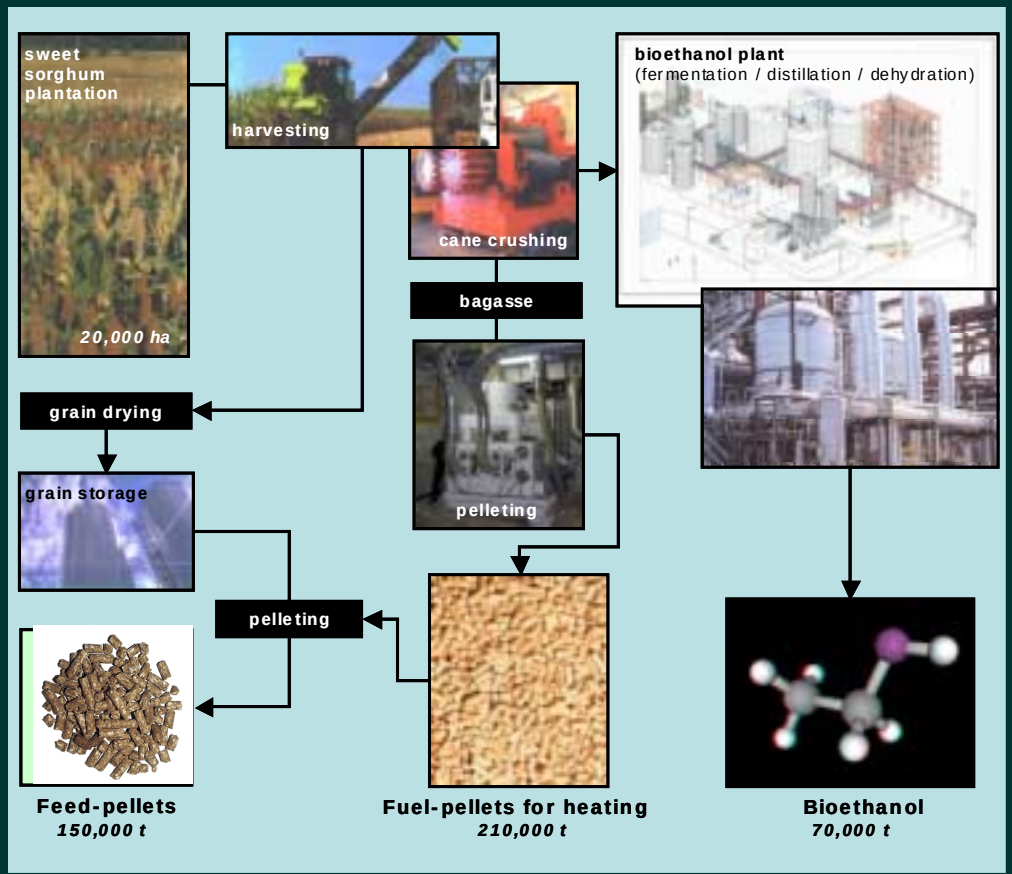
Bioethanol energy activity: very modest
Many countries (following E.C. directive) start to plan significant investments (in particular Germany)
Production cost of anydrous bioethanol from conventional crops (wheat, corn, sugar beets): approx. **500 €/t**
Estimated production cost of bioethanol from most promising crops (e.g. sweet sorghum): **approx. 250 €/t**
Market value: - Europe: 600 €/t - USA: 500 €/t - Import duty: 190 €/t

Concept of sweet-sorghum Biorefinery

Integrated Bio-energy Complex:

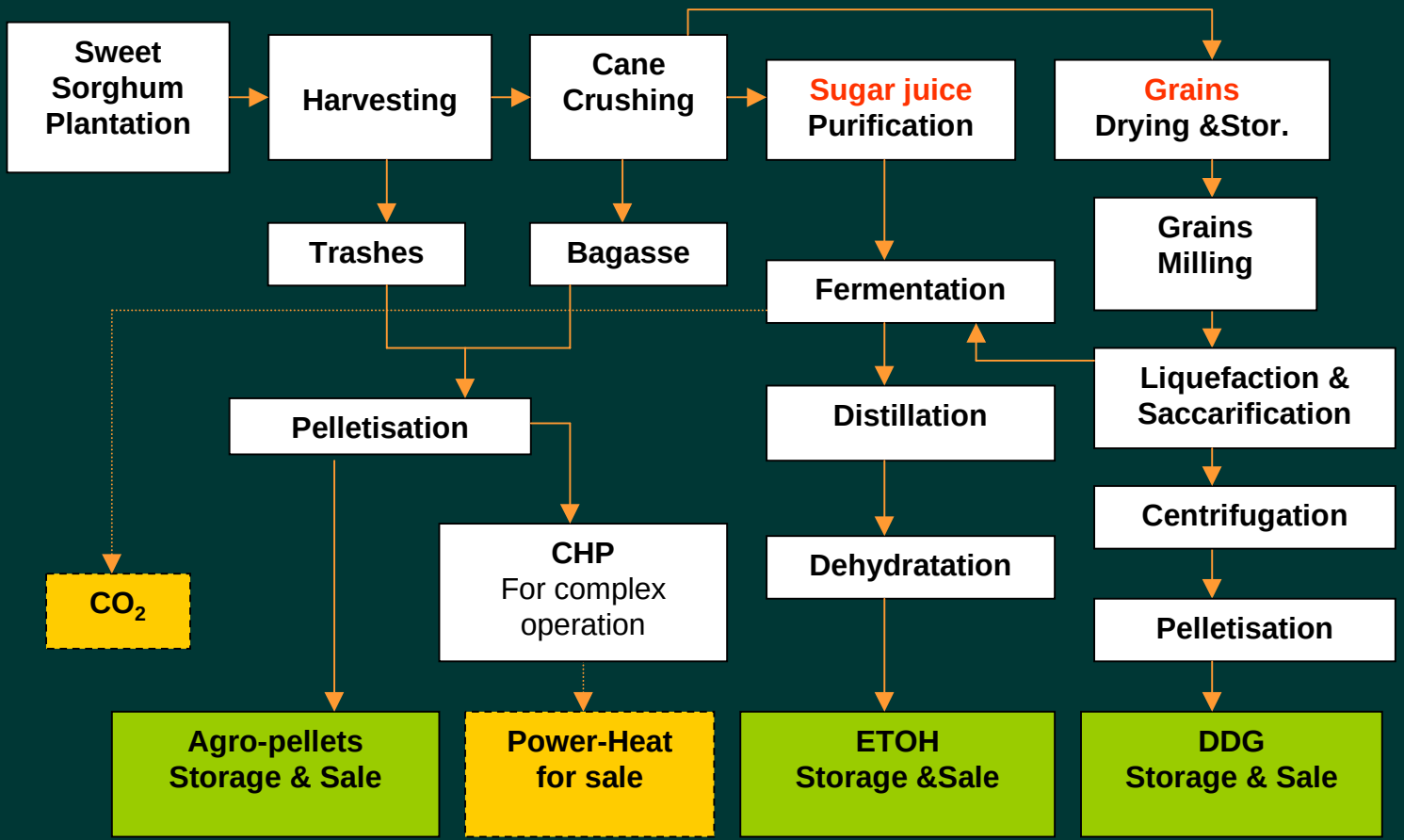
Exploiting all crop components to obtain several products (animal feed, fuel pellets and bioethanol), keeping the priority product “bioethanol” at the minimum cost.

Bioethanol can be produced at **250** €/t



Typical Sweet sorghum integrated process

(simultaneous production of bioethanol + cogeneration + animal feed)



How to reach a low cost for Bioethanol?

- By high productivity (this has been demonstrated)and control in supplying.
- By the valorisation of all components of the crop;(for exemple):

Grains (80€/t)

Sugars (50€/t)

Lignocellulosic (25€/t)

} Sufficient to cover the production cost (850 €/ha)

Assuming that 60% of the ETOH production cost is due to the feedstock (sugar cost) supply, this value is:

$$\frac{50\ €/t}{0.96_1 * 0.93_2 * 0.5_3 * 0.95_4} = 118\ €/t\ ETOH$$

1: Sugar extraction efficienc
2. Fermentation efficiency
3. ETOH/sugar conversion
4: Industrial efficiency

Bioethanol cost from sweet sorghum is ca 200€/t:

Conservative figure: 250 €/t (1/2 of present EU prod. cost!)

Which R.O.I. can be expected ?

- Decentralised Bioethanol production: (~1,000 ha)
  - Investment: 10 mio €
  - R.O.I. ~ 15 - 20 %

- Centralised Bioethanol production: (> 20,000 ha)
  - Investment: ~ 65 mio €
  - R.O.I. ~ 20 - 25 %

The availability of “green-certificates” or “CO_2 trading” could influence considerably the ROI

(With Bioethanol market value: 500 € /m^3)

Social benfits from bioenergy

- **USA**
  - ~ 1 M TOE / year bioethanol from maize
  - **14,860** jobs
    - ~ 7**,980** jobs agric. sector (54%)
    - ~ 5**,320** jobs in industry and services (36%)
    - ~ **1,560** jobs plant construction (11%)
  - ➔ 1 job for 67 TOE bioeth./year
- **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

Enviromental Benefits

- Optimised bioenergy closed schemes (biomass production, conversion and utilisation) present energy ratio: (outputs / inputs) ~ 2 or more. Therefore they are nutral from the CO2 emission into atmosphere and can greately benefit from CO2-trading
- Biomass resources contain very low amounts of sulfur so SO2 emissions during cmbustion are very limited
- Particulate and other regulamented emissions can be contolled by existing commercial technologies
- Biofuels are of geat interest for the transport sector and able to decrease the negative enviromental impact of congested urban areas

Sectorial markets Technologies
(Specific Investment Indicative Figure)

Sectorial market	Technology	Small capacity	Large capacity
Stabilisation of humid biomass	Mechanical drying & pelletisation	~ 460,000€ (1 t/h)	900,000 € (5 t/h)
Heat production	Stoves	120 - 400 €/kWth (6-11 kW)	-
	Boilers	200 €/kWth (50 kW)	170 €/kWth
Power	wood-gasifer + engine	3,000 €/kWe (70-500 kWe)	-
	steam engine generator*	1,300 - 1,600 €/kWe (50-1,000 kWe)	-
	steam condensing plants	2,000 €/kWe (2-4 MW ?=25%)	1,600 €/kWe (10MWe ?=29%)
	co-firing (coal bio-pellets)	-	supplementary invest.: +8 €/kWe (500 – 4,000 Mwe)
	Micro-gas turbine	1000 €/kWe (100 kWe ?=28%)	-
Transport	Bio-diesel production	-	300 €/t (50,000 t/y)
	Bio-ethanol production	400 €/m3 (330d/y op., 6,500 m3/y	300 €/m3 (330d/y op, 100,000 m3/y)
	Bio-gas production	6,100 €/m^3h	3,200 €/m^3h

Evolution of activities

Taking into account the proposed targets (up to 2020), the estimated volume of investment for the different sectorial markets are:

- Stabilisation of humid biomass: ~26 billion €
- Heat market: ~50 billion €
- Power generation market: ~63 billion €
- Biofuels for transport market: ~35 billion €

Bioenergy Total Investment up to 2020:

~ 174 Billion €

The rate of penetration of bioenergy into the different sectors will depend considerably (especially in the present phase of start-up) from the establishment of policies related to common EU rules and from support measures as "CO_2-trading", "green-certificates", SO_2 mitigation,NO_x reduction, investment support for the creation of supplementary jobs (in substitution of conventional energy import).

The level of total direct job creation in the EU (corresponding to a volume of ~0,5 billion t of biomass utilised per year) is huge and estimated at ~1 million new jobs.(only biomass production & recovery)

Evolution of activities

List of activities with large potential impact:

(Some not requiring financial support)

1. **Coal-biomass Cofiring** (31 % of power in the EU is derived from coal. A first target of 10% level of cofiring would mean a fast 20,000 MWe contribution , requiring ~70 mio t/y of dry biomass. An innovative EU technology, now appearing on the market can makes this option technically, operational, economically feasible.
2. **Industrial agro-pellets steam-production**;
3. **District heating** (requiring high investment in infrastructures);
4. **Transport biofuels** (Biodiesel-Bioethanol)
5. **High- quality steel**
   (requiring 0,5-1 t of siderurgical charcoal pellets for 1 ton of steel).
6. **Industrial Biohydrogen** /power /heat production from agropellets for crude-oil refining**.**
   (~10% of its energy flow consumed for heat/power in the refinery + ~1% H2 of its mass flow)

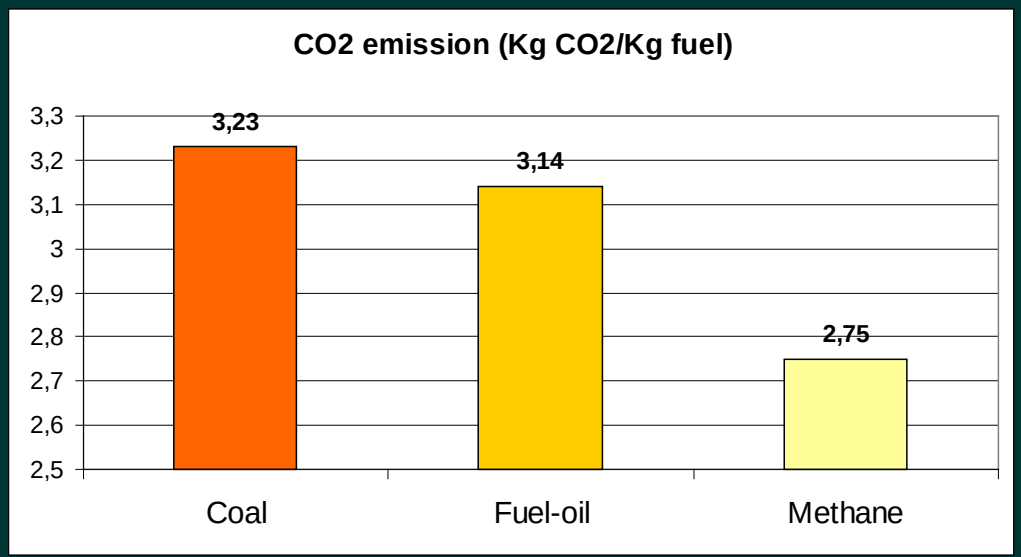
Bioenergy benefits from policy supporting measures

Simple supporting measures could accelerate the large scale deployment of bioenergy activity in the EU and world wide.

Here below some economic-effects are briefly summarised:

1. CO_2 – trading

Considering that the CO_2 emissions into the atmosphere during the combustion for different fuels are as follows:



Policy supporting measures

The substitution of biofuels (solid – liquid - gaseous) to conventional fuels can reduce considerably the CO_2 emissions.

In particular:

- 1 Kg of pellets saves ~ 1,5 Kg CO_2
- 1 Kg of bioethanol saves ~ 2,2 Kg CO_2
- 1 Kg of bio-H_2 saves ~ 7 Kg CO_2

Therefore assuming a CO_2-trading of ~40 €/Kg CO_2, the average production price of agro-pellets will be reduced drastically from:

100 €/t ? 42 €/t future potential agro-pellets price (large scale)

Therefore agro-pellets* could become energetically competitive with imported coal of a price ~64 €/t

Coal/agropellets cofiring could reach high level of operation (technically ~ 20-25%) with large impact on rural development

*agro-pellet is better than coal (absence of S and lower amount of noxious ashes)

Policy supporting measures

2. Green Power certificates

Assuming an “average green certificates” value of 0,1 €/kWhe, the price benefits of agro-pellets for the production of bioelectricity could be (depending on the technology):

~ 140 – 190 €/t (pellets)

Becoming a competitive biofuel in substitution of imported coal!

3. Defiscalisation of Biofuels for transport

Partial or complete defiscalisation measures have already introduced in some EU countries

4. Support to investment

The accumulated man-power new jobs income taxation (+20%), during the lifetime operation of a bioenergy plant, is similar to the required investment

Financing Know-how Transfer

• Because the availability of commercial technologies is limited, in many cases the transfer of technologies and know how is opportune to:

- accelerate its deployment;

- reduce the risk and the cost of its own technology deployment and commercialisation

• For decentralised Bioenergy production (small size technologies) on wich SME are most involved, the cost of technology and know-how transfer is reasonable:

1 – 5 M€ with 10% royalty

• For Developing Countries the mechanism of technology transfer is vital;

• JDM-schemes, CO_2-trading, “green certificates” sale could provide important financial support for expansion of activity

• To reduce the operation and financial risks of projects in developing Countries, the establishment of joint ventures between local Co and organisation of industrial countries is critical

Conclusion

- The world biomass potential is considerable 5,650 MTOE/y (2050)
- The technical EU 25 Biomass Potential is considerable:
  600 MToe/year (year 2020, 38% of total consumption)
- Some bioenergy activities are already economically viable
  (heating, cofiring, etc)
- Integrated processing of biomass resources improves the economics
- Some policy measures are vital to accelerate the deployment of bioenergy
- For the accomplishment of the proposed bioenergy targets the estimated total investment (up to year 2020) is estimated at
  ~ 174 Billion €
- A significative volume of export activities can also be envisaged
- International competition is going to play an important role

Thank you for your attention!

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