Overview of the markets for energy crops in EU27

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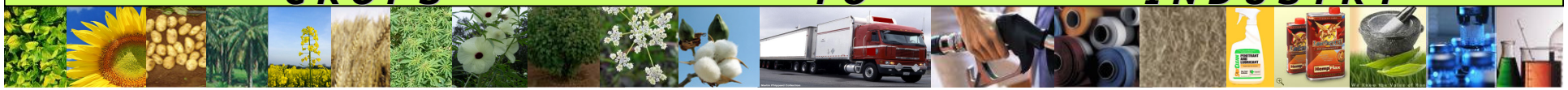
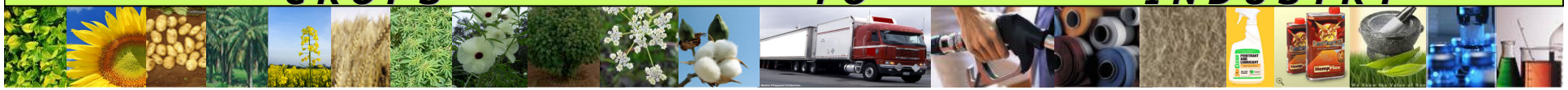


The energy markets in EU27

Bio-products	Current markets	Growth trends (2020)
Energy		
Solid biomass	EU27: 74.5 Mtoe	195-230 Mtoe for solid biomass and wastes according to European Commission (COM2006/848)
Wastes	EU27: 6.6 Mtoe	
Biogas	EU27: 8.1 Mtoe	48 Mtoe in EU-27 in 2020 (source: German Biomass Research Centre, European Biogas Association (EBA) and AEBIOM)
Fuels		
1st generation	EU: 10.2 Mtoe (8 Mtoe biodiesel) (1.2 Mtoe bioethanol)	Average annual growth 28.2% biodiesel; 12.8% bioethanol
2nd generation		



The non-energy markets in EU27

Bio- products	Current markets	Growth trends (2020)
Pulp & paper		
Paper (wood fibres/ starch) and paperboard	EU paper/ cardboard: 40 Mtoe	
Biomaterials		
Fibre- based/ composites	50 Ktoe in automobile industry, 3.5 ktoe in construction	100 Ktoe in auto industry by 2010; biobased could reach 5- 30 % in 2020
Bioplastics; Biopolymers	EU: 50 Ktoe out of total 73 Mtoe	30% production increase in recent years; 5% market share of packaging plastics by 2010
Surfactants	EU: 30% out of total 2.5 Mtoe	New markets: Plant health products; 60-65% of detergents could be of vegetable origin
Biosolvents	Currently 1.5 % of total (60,000 tons out of 4 Mtoe)	Could grow to 12-40%.
Biolubricants	2% of total (100 Ktoe from 5Mtoe); mainly in hydraulic sector; low use in automotive	30% of market share by 2010
Pharmaceutical products incl. Vaccines	Currently high value/ low volume niche markets.	New product opportunities with high market/ growth potential.
Enzymes	53 Ktoe in 2001 (3/4 in EU)	5% annual growth rate

Support framework for the energy market

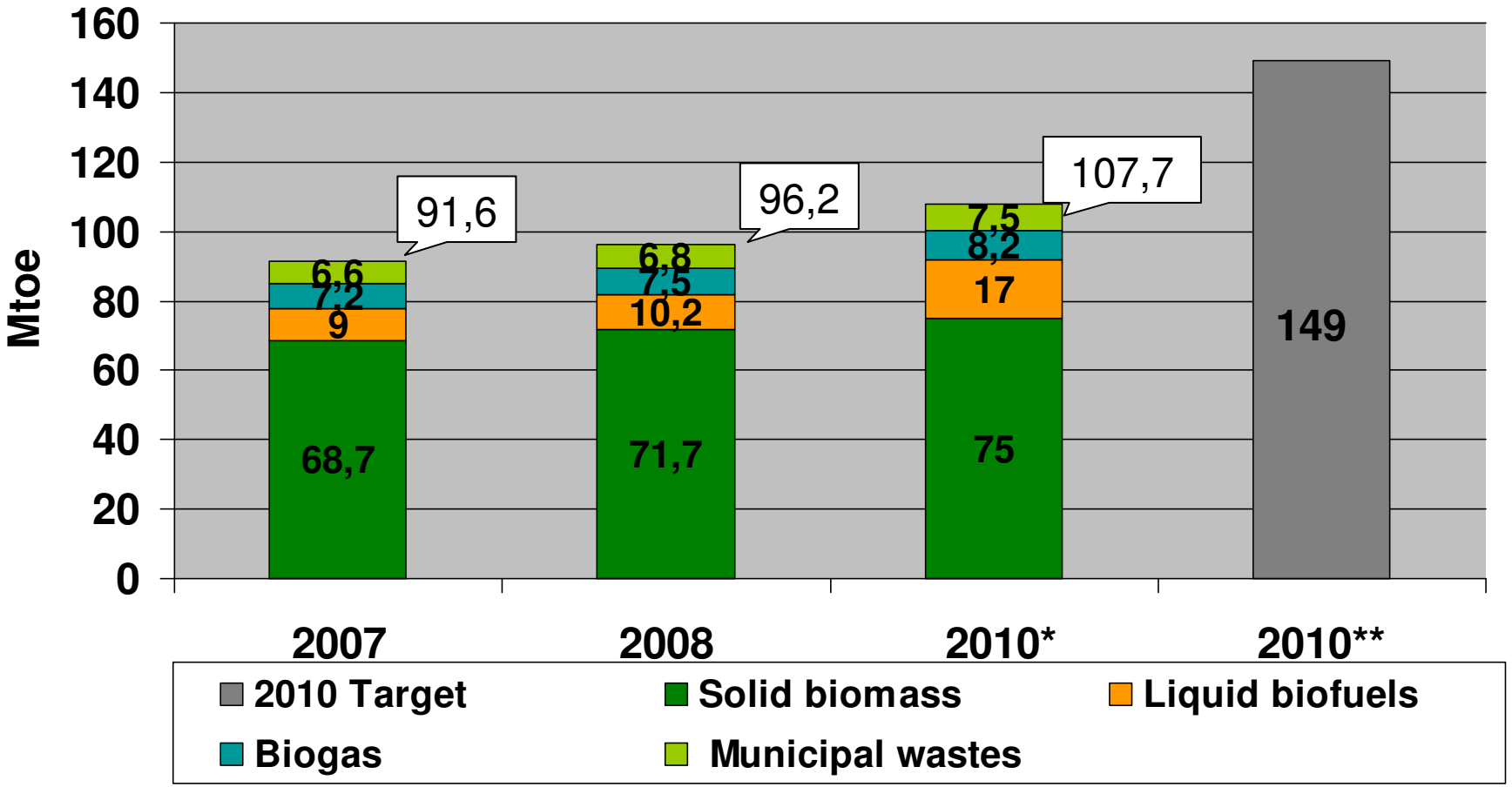
Numerous legal documents, reports and support frameworks at EU27 and M-S level

- EU Renewable Energy Directive (2009/28/EC), with the following targets by 2020:
  - ✓ Reducing greenhouse gas (GHG) emissions by at least 20% from 1990 levels;
  - ✓ Improving energy efficiency by 20%;
  - ✓ Raising the share of renewable energy to 20%;
  - ✓ Increasing the level of biofuels in transport fuel to 10%.
- The Biomass Action Plan (COM(2005) 628) with emphasis to combined use of biomass for heat & electricity, as well as for transport, by setting out a number of alternative or complementary measures to boost the development of energy crops through market-based incentives.

AEBIOM has also defined a set of target for energy crops to satisfy EU policy. These targets are expected to use 25 Mha, and comprise of individual targets for each sector:

- ✓ 15 Mha for liquid biofuels
- ✓ 5 Mha for biogas
- ✓ 5 Mha for solid biomass

Primary bioenergy consumption in EU27

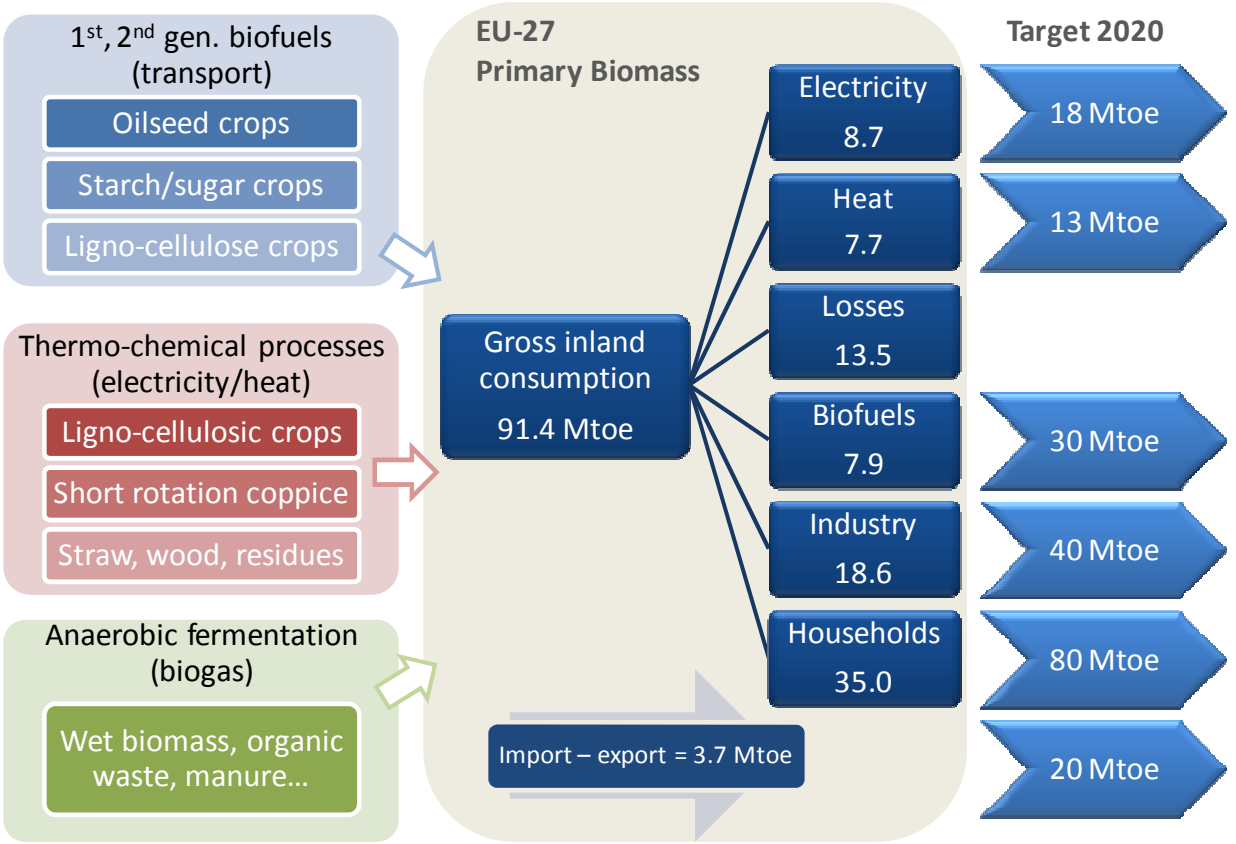


EurObserv'ER 2009

* Estimations from EurObserver

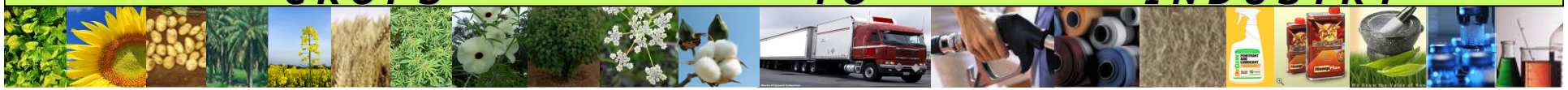
** Expectations from the Biomass Action Plan

Biomass trade in EU27 in 2007: primary sources, uses and targets in 2020.



- Of the 91.4 Mtoe, about 70-80 Mtoe were used for energy according to AEBIOM and EUBIONET3 Project
- The contribution of energy crops on total biomass use is still very little, i.e. 4% including biofuels and only 0.4% (0.05 Mtoe) considering only the direct burning of solid biomass (about 50-60 Mtoe).
- The bioenergy market accounts for about 55% of industrial crops; it involves heating/cooling, electricity and transport

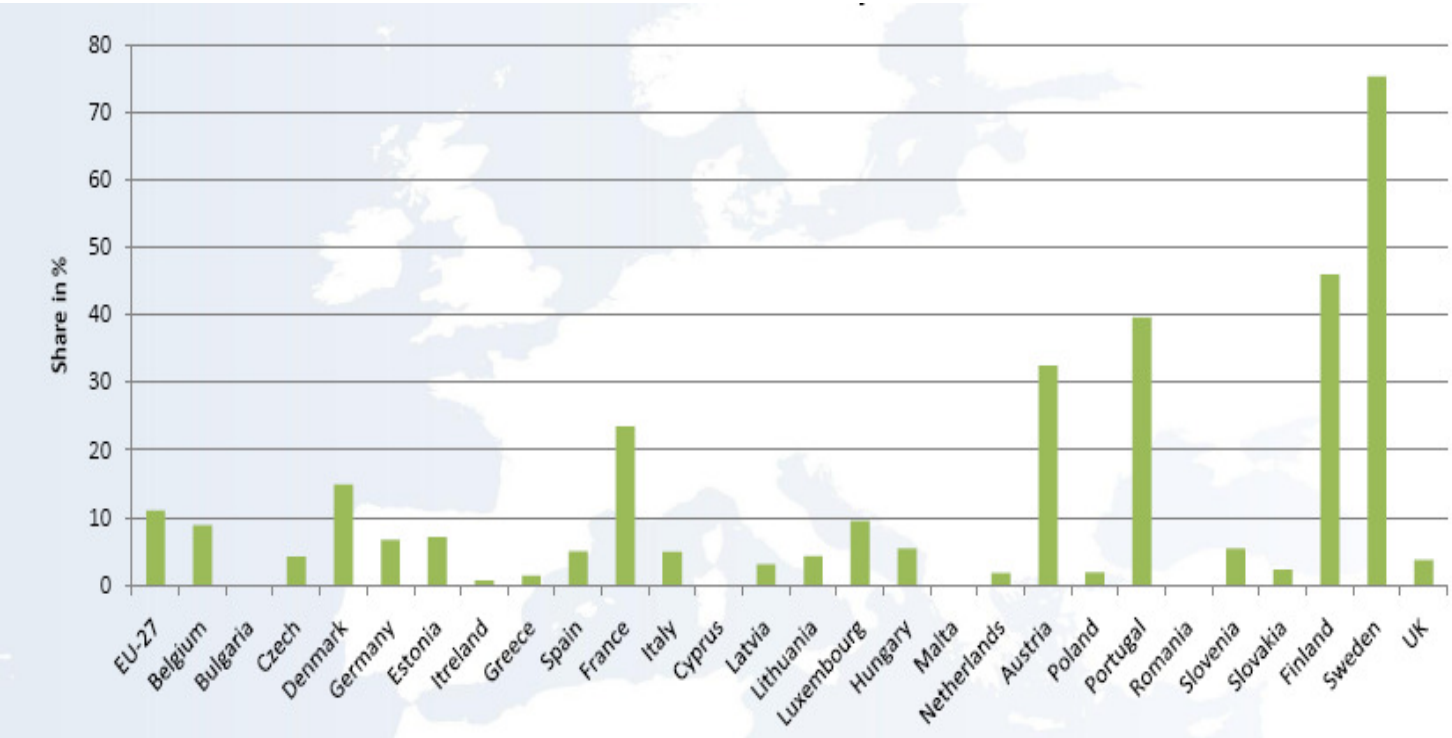
- Biomass is likely to contribute to around two-thirds of the expected renewable energy share in 2020 (PRIMES projections) in terms of primary energy consumption. About 230-250 Mtoe of bioenergy are needed to meet the EU's target of 20% share of renewables.
- A key question is how can this target be met in an economically and sustainable manner without causing major distortions in the food, feed and other respective markets.
- Accounting for food and feed requirements, it was estimated that some 22-46 Mha (up to 72 including Ukraine) could be freed up for growing bioenergy crops by 2030. Similar results were obtained by EEA and the 4FCrops project.
- Central and Eastern European Countries (CEEC) are expected to expand significantly the biomass crops production potential. In Bulgaria, Poland, Romania and Czech Republic about 33 Mha could become available for bioenergy crops by 2030 with a corresponding energy potential of almost 12 EJ (288 Mtoe).



Bioelectricity and bioheat markets

- **Bioelectricity through combustion** followed by a water vapour cycle is the main current technology. **Co-combustion of biomass and coal** is also under implementation by electric utilities. There are already plants with innovative CHP systems like **Organic Ranking Cycle (ORC), gasification and stirling engines**.
- Among bioenergy conversion systems, **bioheat** mainly through **combustion** is the highest effective process to produce energy and one of the higher shares in energy from biomass.
  - **Small-scale heating systems** for households typically use firewood or pellets.
  - **Medium-scale users** typically burn wood chips in grate boilers
  - **Large-scale boilers** able to burn a larger variety of fuels, including wood waste and refuse-derived fuels.
  - **Medium or large scale cogeneration plants** for industrial processes to supply district heating networks.

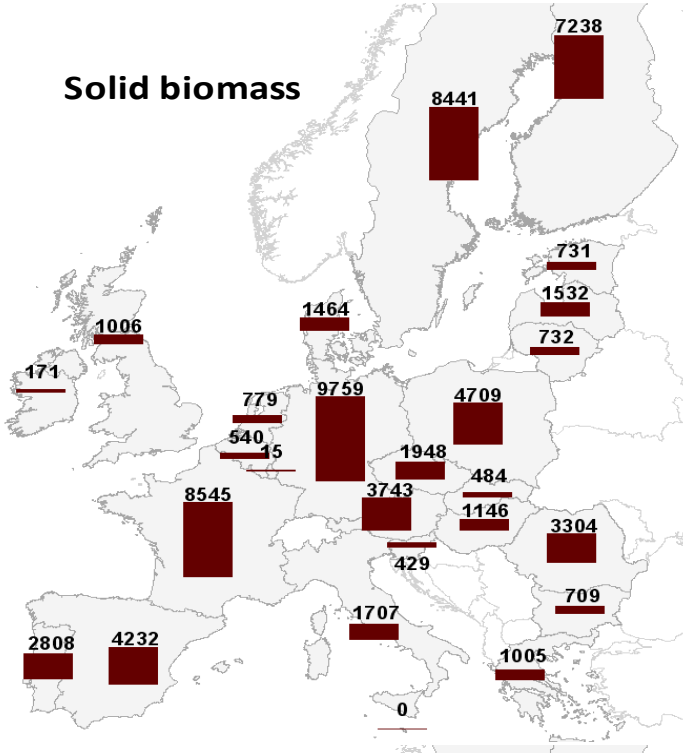
Biomass share in CHP plants in EU27 & Member States



- CHP plants account for almost 63% of EU-27's bioenergy production from solid biomass
- Most of them are located in countries of considerable forest industry
- Smaller capacities (< 1 MWe) exist in central Europe, while larger plants (>20 MWe) are located in Northern Europe
- Key issues facilitating the market development in these countries are the existence of district heating networks and the strong support policies for respective schemes

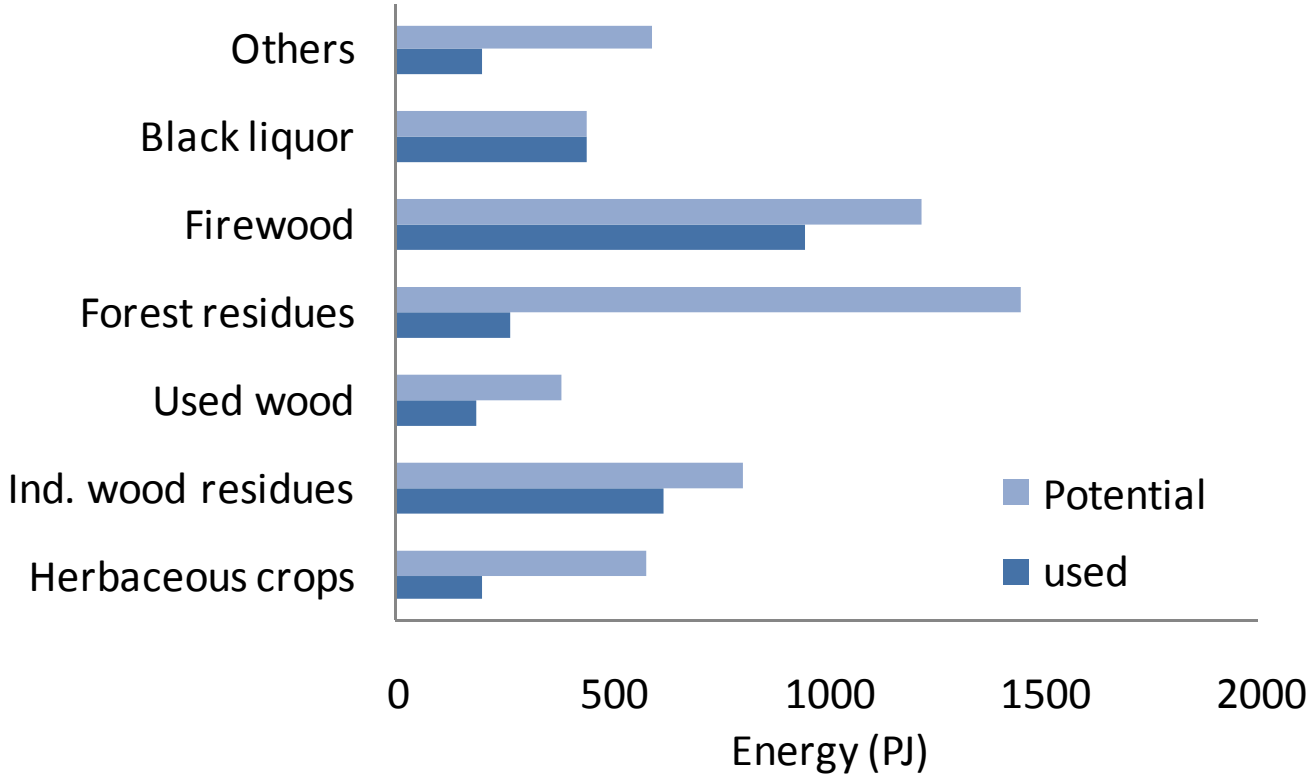
Bioelectricity and bioheat markets

- **Bioelectricity** production from solid biomass reached 57.4 TWh in 2008, compared to 20.3 TWh in 2001 (when EU issued the Directive on the Promotion of Electricity from RES.
- More than the half of bioelectricity production is still concentrated in **Germany, Sweden and Finland.**
- AEBIOM estimated that almost 50% from the EU27 final bioenergy consumption (1158 Mtoe in 2007) derived from **bioheat**, reaching up to 448 Mtoe for the respective year. Solid biomass dominated the bio-heat sources accounting for over 97% of the total market. The industrial and domestic sectors dominate
- Nonetheless, M-States seem reluctant to support the heat production from solid biomass



Bioenergy production from solid biomass across Europe (EU27) in 2008 (in ktoe)
Source: EurObserver

Major solid biomass: potential and current use in EU27 in 2007 (from EUBIONET3 project).

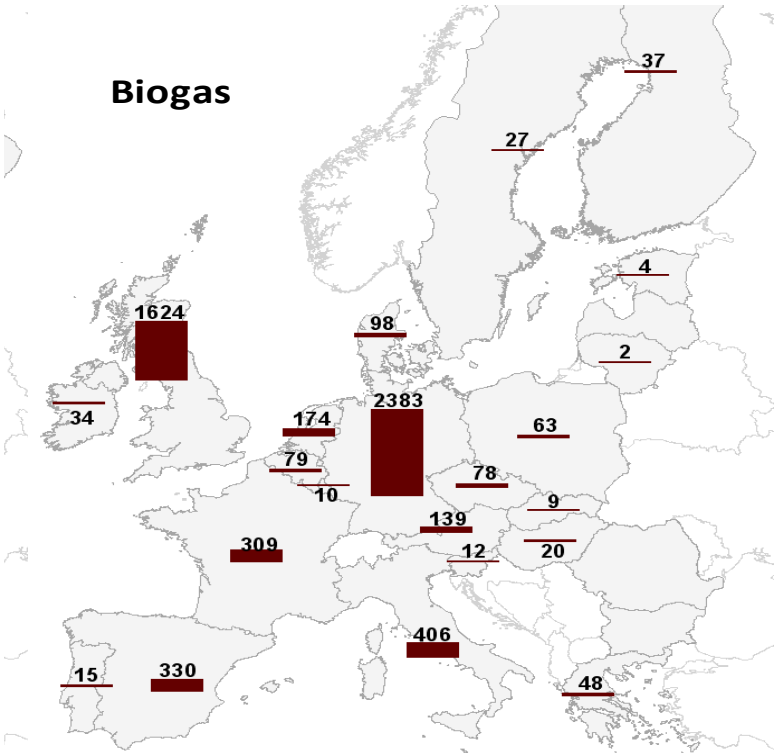


Biogas

- Biogas production in EU27 was about 7.5 Mtoe in 2008 (tripled since 1995) .
- It is mostly concentrated in the EU15 (about 95%), especially in **Germany and UK**, but other countries like **Austria** (350 units in 2007), **Denmark** (160 units) and **Sweden** (233 units) also support the biogas sector.
- **Germany** alone produces about 40% of the total biogas with an impressive increase (+43%) from 2006 to 2008.

  At the end of 2008, about 3.800 methanisation units were operating in Germany (250 more than in 2006 despite maize price increased by 83%).

  Most of these units are cogeneration plants up to 500 KWe thanks to the incentives and new laws on renewable energies by the German government.



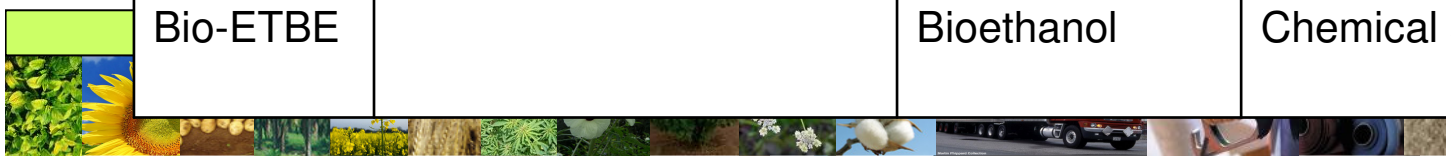
Bioenergy production from biogas across Europe (EU27) in 2008 (in ktoe)
Source: EurObserver

Biogas

- **Bio-energy crops and agricultural residues accounted for less than 17% of total production**; the majority of biogas derived from landfill (about 60-65%) and sewage sludge (about 20%).
- The primary sources used for biogas production differ among M-S
  - UK mostly produces biogas from landfill (88%),
  - Germany uses agricultural sources (e.g. **maize, sunflower and wheat**) in small farm methanisation units.
- Biomass-to-biogas conversion generates two kinds of added value by-products: the solid digestate which may be used as ameliorative of soil fertility, and a liquid digestate that can be used as fertilizer.
- Apart for heat and electricity, biogas can be used for transport. In EU-27, the natural-gas vehicles (NGV) are about 1.3 million (2009), with an average annual growth of about 25%. It should be recognized that the relative growth of NGV worldwide is much higher than that for gasoline vehicles.

First generation biofuels

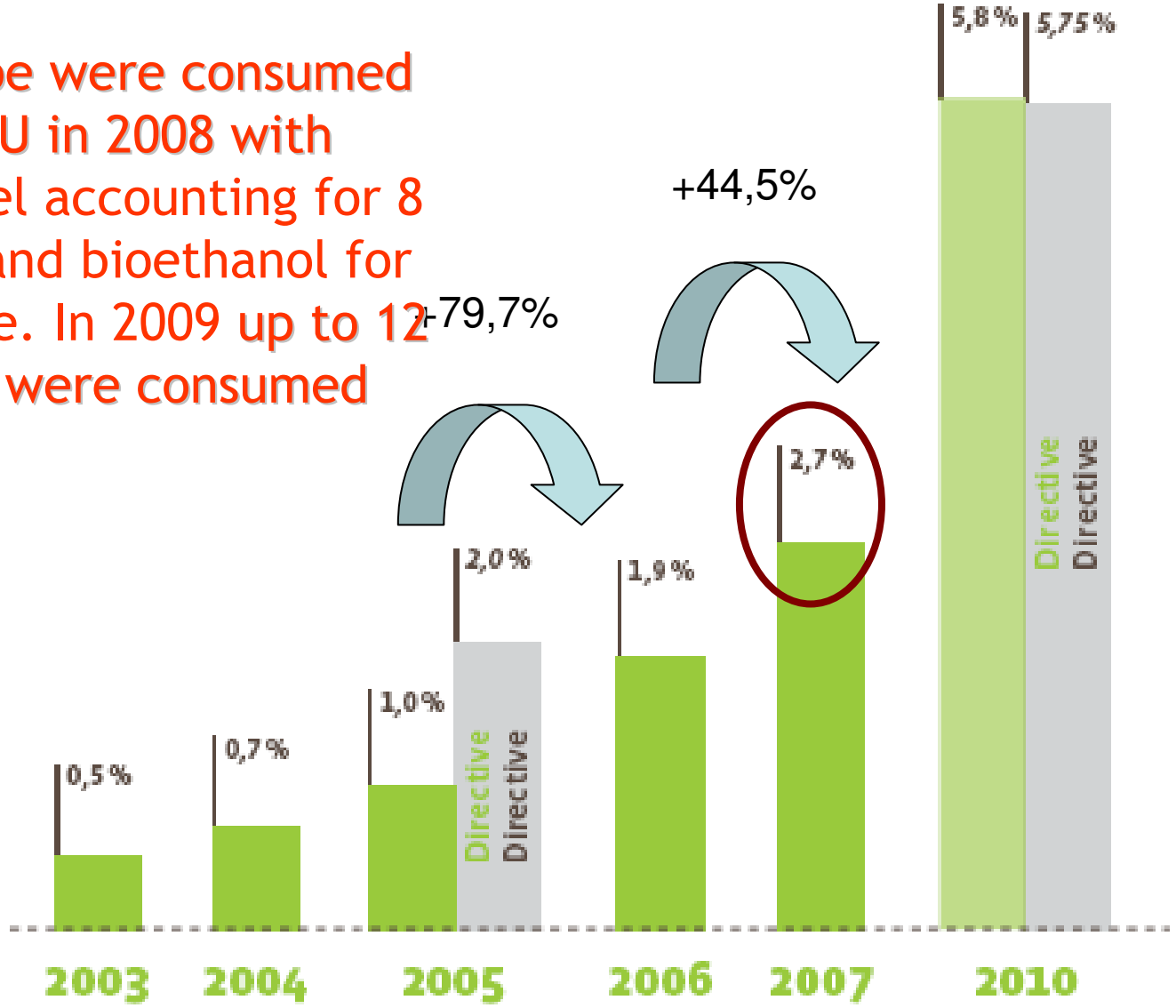
First generation biofuels			
Biofuel type	**Specific biofuel**	**Biomass feedstock**	**Production process**
Bioethanol	Conventional bioethanol	Sugar beet, grains	Hydrolysis and fermentation
Vegetable oil	Pure plant oil	Oil crops	Cold pressing/extraction
Biodiesel	Biodiesel from energy crops	Oil crops	
	Rape seed methyl ester (RME)		Cold pressing/extraction & transesterification
	Fatty acid methyl/ethyl ester (FAME/FAEE)		
Biodiesel	Biodiesel from waste	Waste frying oils, animal fats	Transesterification
	FAME/FAEE		
Biogas	Upgrated biogas	Wet biomass	Anaerobic digestion
Bio-ETBE		Bioethanol	Chemical synthesis



Source: ETP Biofuels

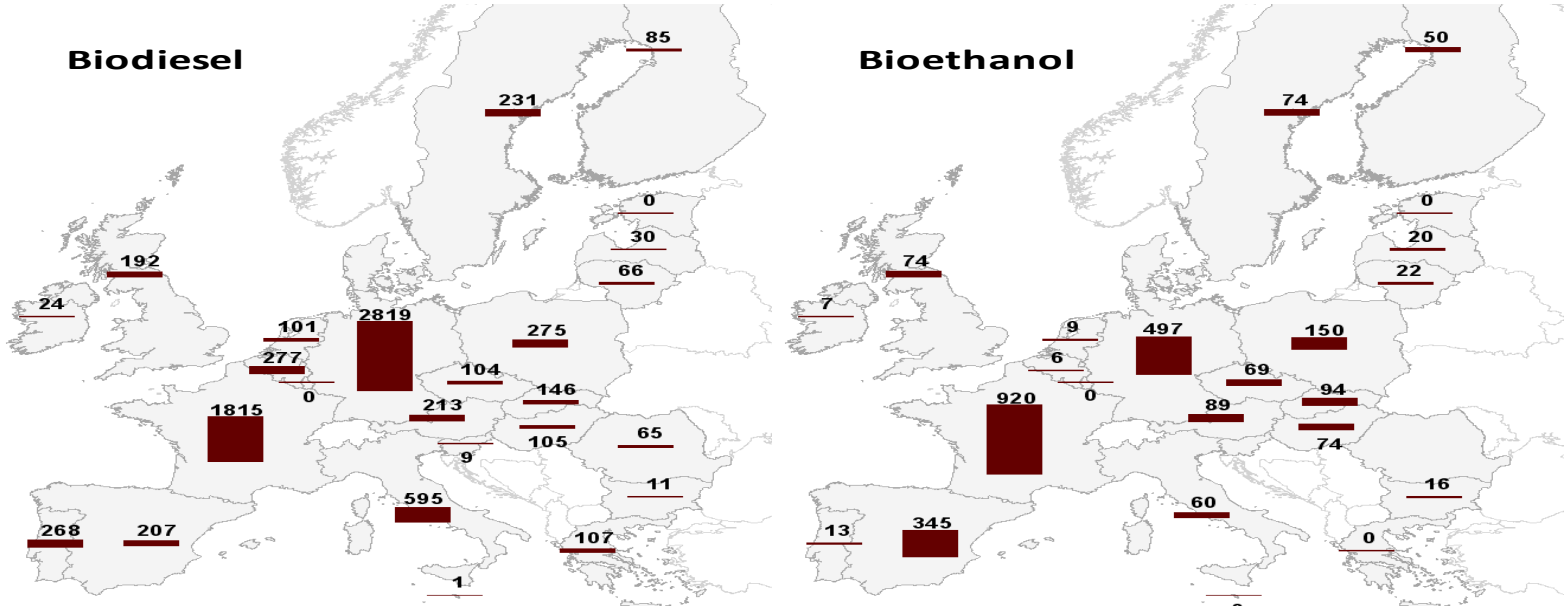
Comparison of current trend with the directive on liquid biofuels for transport (2003/30/EC)

9.2 Mtoe were consumed in EU in 2008 with biodiesel accounting for 8 Mtoe, and bioethanol for 1.2 Mtoe. In 2009 up to 12 Mtoe were consumed



Source: EurObservER 2008

Biodiesel (in t*10^3) and bioethanol (in l*10^6)production across Europe (EU27) in 2008 (from EurObserver)



- 120 biodiesel plants operate in EU27, mostly located in Germany and France, and produce about 7.7 million metric tons in 3 Mha of arable land. Hereof, 85% are cultivated with **rapeseed** and rest are **soybean and sunflower**.
- The inland biodiesel consumption is almost 80%, while imports from developing countries is expected to increase
- EU27 produced only about 2800 ML in 2008, with France being the leading producer with a massive increase from 2005 (144 ML) to 2008 (950 ML). Spain Germany, Hungary and Poland follow. The rest of EU27 countries showed insignificant or even decreasing productions. The main crops are **cereals** (70% in 2008), and to a much lesser extent, **sugar beet**. Sweet sorghum is regarded as a good future option.

First generation biofuels

Current status

- Mature technologies
- Commercial markets
- Feedstock and fuel trade
- Competition with food and fiber
- High production costs
- Usually blended into fuel in small proportions (5-10%), providing useful, but limited, reductions in net greenhouse gas emissions.

Feedstock supplies

- Agricultural crops, predominantly produced as food crops (sugar, starch and oil crops)
- Energy crops, bred and grown for energy purposes
- Wastes

Second generation biofuels

Second generation biofuels			
Biofuel type	**Specific biofuel**	**Biomass feedstock**	**Production process**
Bioethanol	Cellulosic bioethanol	Lignocellulosic material	Advanced hydrolysis & fermentation
Synthetic biofuels	Biomass-to-liquids (BTL):	Lignocellulosic material	Gasification & synthesis
	FT-diesel		
	Synthetic bio-diesel		
	Biomethanol		
	Heavier-treated biodiesel		
	Biodimethylether (Bio-DME)		
Biodiesel	Hydro-treated biodiesel	Lignocellulosic material	Hydro-treatment
Biogas	SNG (Synthetic Natural Gas	Lignocellulosic material	Gasification & synthesis
Biohydrogen		Lignocellulosic material	Gasification & synthesis or Biological process

Second generation biofuels

Current status

- Use of non-food/non-intensively farmed crops and wastes
- Use of marginal lands
- Enhanced conversion efficiencies/yields
- Improved fuel characteristics enabling blending with conventional fuels in higher proportions without vehicle modifications
- Relatively immature technologies
- High production costs, high commercial risk
- Significant RTD funding is occurring worldwide

Feedstock supplies

Lignocellulosic materials (low cost energy crops, agricultural-forest residues, wood processing wastes)

Main crop options for energy, fuels and materials in EU 27

Crop category	Main product/ co- products	Market (s)	Cost ranges (€/ GJ)
Oil crops *Rapeseed,* *Sunflower* *Ethiopian mustard*	Heat and/or power Biodiesel (FAME)	Bioenergy	15- 20
	Biofuel (HVO)	Bioenergy	
	Lubricant	Biomaterial	
	Surfactant		
Sugar crops *Sugar beets* *Sweet sorghum*	1,3-PDO	Biomaterial	
	Fuel ethanol	Bioenergy	8-12 (sugar beet) 2.5-4 (sweet sorghum)
	Chemical ethanol	Biomaterial	
	Ethylene		
	Insulation mat		
Lignocellulosic crops from woody and herbaceous biomass *Reed canary grass* *Miscanthus,* *Switchgrass* *Giant reed,* *Cardoon* *Willow,* *Poplar* *Eucalyptus*	Heat and/or power	Bioenergy	2-5
	FT-Diesel		
	Ethylene	Biomaterial	
	Fuel ethanol	Bioenergy	3-5
	Chemical ethanol	Biomaterial	
	1.3 - PDO		
	Ethylene		

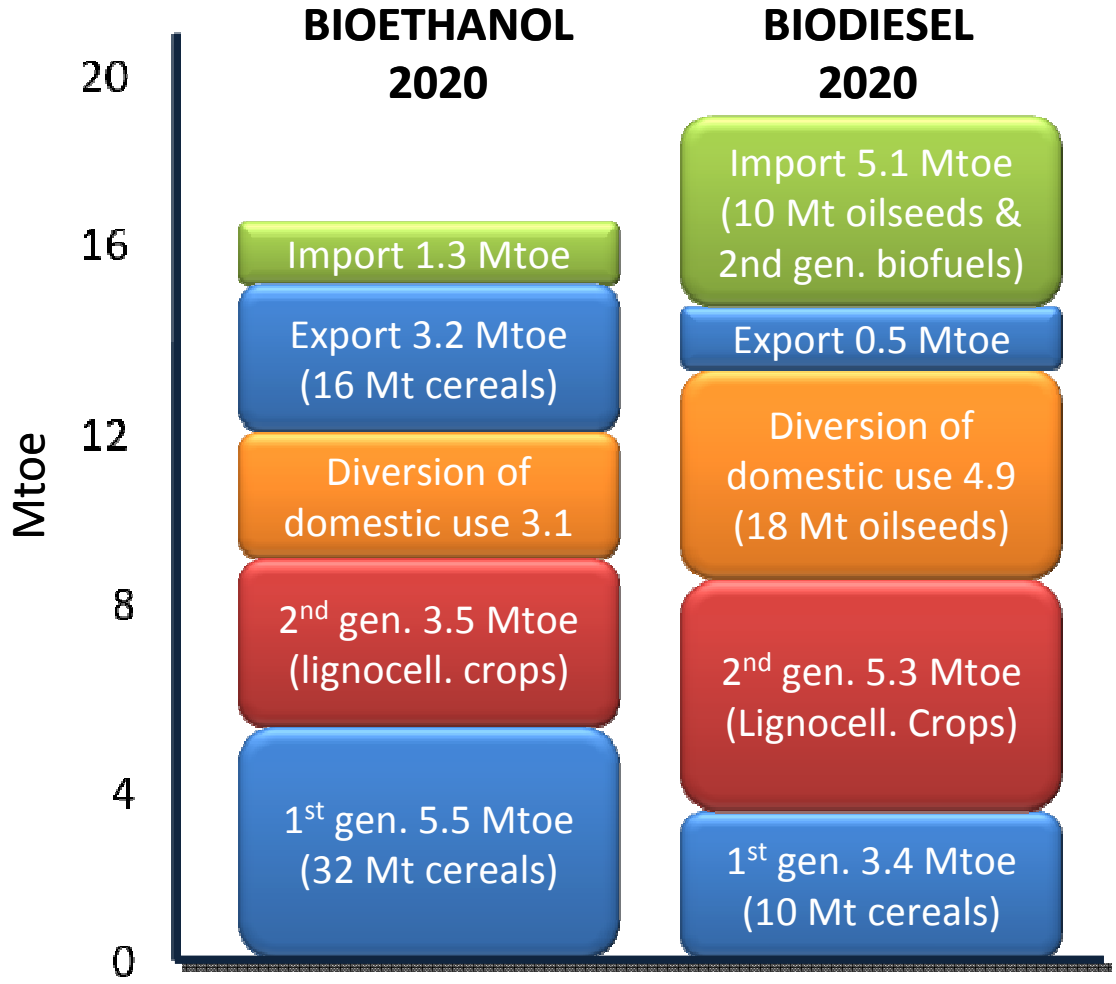
Key issues for integrating bioenergy crops in EU energy markets

- Ensuring the “good use” of both the primary source and co-products, whilst optimizing the logistics.
  - efficient land use;
  - both primary production and residues are evaluated for the energy potential;
  - sustainability of production- handling techniques;
  - alternative biomass markets.
- Strengthening the communication between farming-forestry sectors and respective fuel and energy sectors.
- Land competition for food, feed, fiber, chemicals and energy

Key issues for integrating bioenergy crops in EU energy markets

- Currently low-input, low-output production system is generally not profitable for the farmer. Thus
  - ultimate products carry high unit costs and severely limit the economic viability of the whole chain.
  - many more hectares are required thus the unit impact on the environment is often much greater than from a more intensive system.
- Cultivating marginal land with the same crops as good land cannot return a profit, whether used for energy, industrial feedstocks or food, feed and fiber.
  - Planning efforts should focus on choosing the best available cropping solutions for each region and land type, according to high energy and cost efficiencies, adequate GHG savings, priority to food and feed requirements, soil and water protection etc.

Biomass sources for biofuels production (bioethanol and biodiesel) in EU27 in 2020



(from DG Agri, modified).

Energy crops roadmap from 2010 to 2030

2030	Ligno-cellullosic Algae **(out of the food Chain..)**	Biorefineries
2020	Tailored crops & Systems	Electricity/ CHP Biofuels (2nd gen) Biorefineries
2010	Oilseeds Grains	Biofuels

Conclusions and recommendations

- Despite high expectations with biomass use, the commercial marketplace of energy crops still faces a number of barriers (competitiveness with fossil fuels, technical constraints of feedstocks, low energy density and logistic issues, lack of certification and regulation criteria, land use conflict with food and feed crops, uncertain and undefined environmental and social benefits etc).
- Nonetheless, there is more than one reason to believe that energy crops will steeply develop in the near future and the fact that there are already examples of concrete international bioenergy trade is further convincing.
- Growing energy crops for bioenergy or biofuel gives farmers the opportunity to diversify their production and can provide an outlet to traditional cropping options.
- However, the bioenergy market is still in its infancy, and to be implemented it needs realistic and coherent roadmaps and policy initiatives aiming at boosting the use of bioenergy, while encouraging the private investments in this sector. Therefore, further research on crops and technology, demonstration projects, appropriate certification and regulation systems is necessary.