Biofuels

In the 21st century

What are biofuels and why are they important?

Biofuel is a fuel made from living things, or the waste of a living thing.

Biofuels and biofuel blends

aren't quite a new category of transportation fuels and are defined as liquid fuels and blending components produced from renewable biomass feedstocks used as alternative or supplemental fuels for internal combustion engines.

Biofuels can be in the form of solid and gas as well as liquid fuel.

Biofuels are liquid or gaseous transport fuels such as biodiesel and bioethanol which are made from biomass. They serve as a renewable alternative to fossil fuels in the EU's transport sector, helping to reduce greenhouse gas emissions and improve the EU's security of supply.

By 2020, the EU aims to have 10% of the transport fuel of every EU country come from renewable sources such as biofuels. Fuel suppliers are also required to reduce the greenhouse gas intensity of the EU fuel mix by 6% by 2020 in comparison to 2010.

Because biofuels differ from conventional fuels with respect to their physical, chemical, and biological properties, their introduction poses challenges with respect to understanding the potential impacts of releases to the environment. Specifically, once released into the environment, these fuels will exhibit different environmental behaviors as compared to conventional fuels.

Main bioenergy feedstocks

- Wood
  - Forest management residues
  - Fuel timber
- Crops
  - Annual (cereals, oilseed rape, sugarbeet)
  - Perennial (miscanthus, reed canary grass, short rotation coppice)
- Wastes
  - Straw
  - Animal manure

Source: Mortimer, 2007

Why people are interested in bioenergy?

- Climate change – CO_2 reduction
- Energy security
- Diversification of farm activities;
- Rural development
- Biofuel technology is land intensive

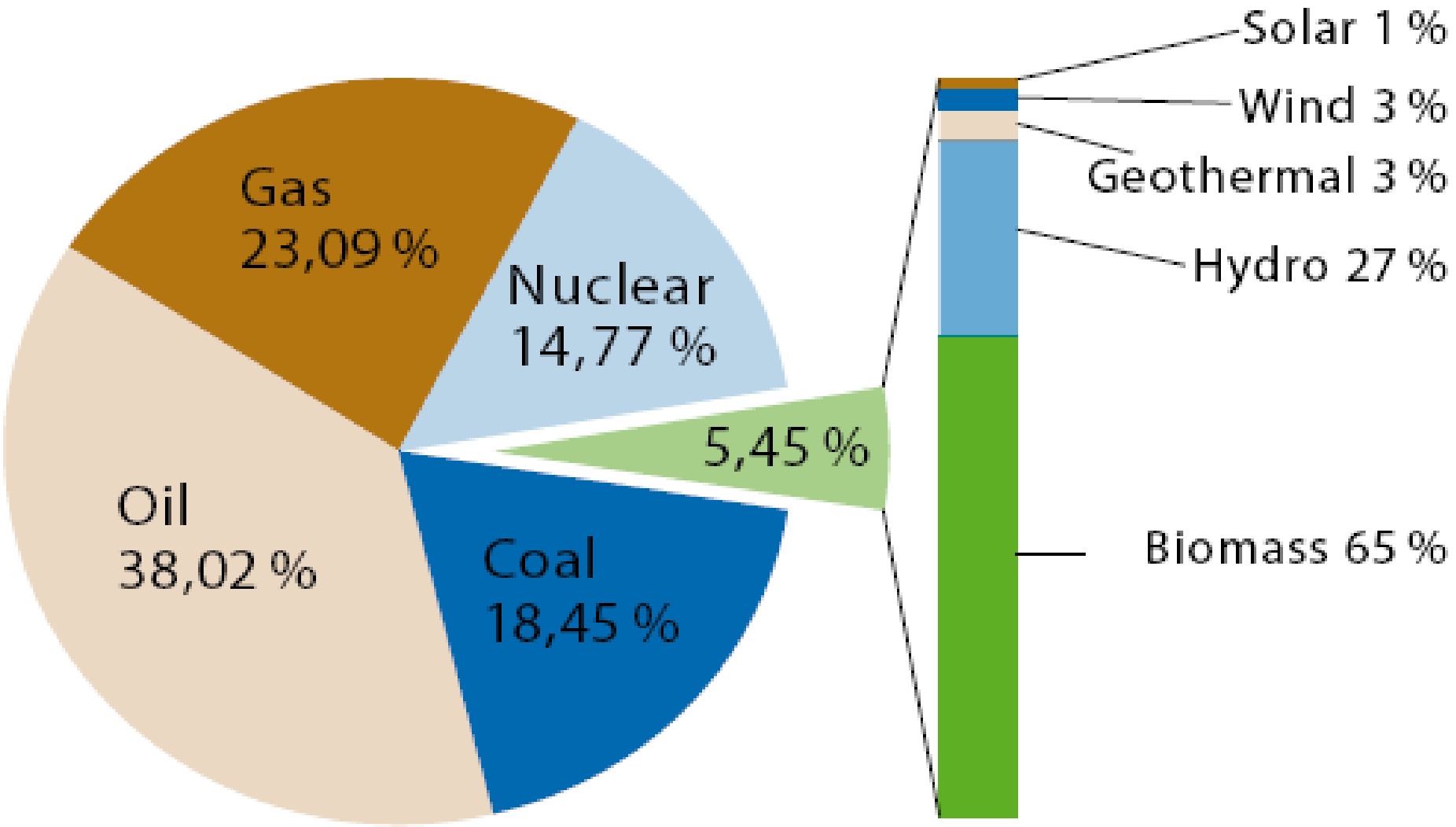
The EU perspective

"There has never been a better moment to push the case for biofuels. Crude oil prices remain high. We face stringent targets under the Kyoto Protocol. And the recent controversy over imports of Russian gas has underlined the importance of increasing Europe's energy self-sufficiency. Raw materials for biofuel production also provide a potential new outlet for Europe's farmers, who have been freed by CAP reform to become true entrepreneurs."

Mariann Fischer Boel, Commissioner for Agriculture and Rural Development, 8 February 2006

Source: Commission, Fact Sheet on Biofuels, 2006

Breakdown of Energy Consumption in the EU-25 in 2002 (source Eurostat)



Source: Commission, Fact Sheet on Biofuels, 2006

Main questions

- What is economic viability of biofuel production?
- What polices are in place to promote production and use of biofuels?
- What will be effect of biofuels on agricultural land use and markets?
- Are current biofuels policies sensible?

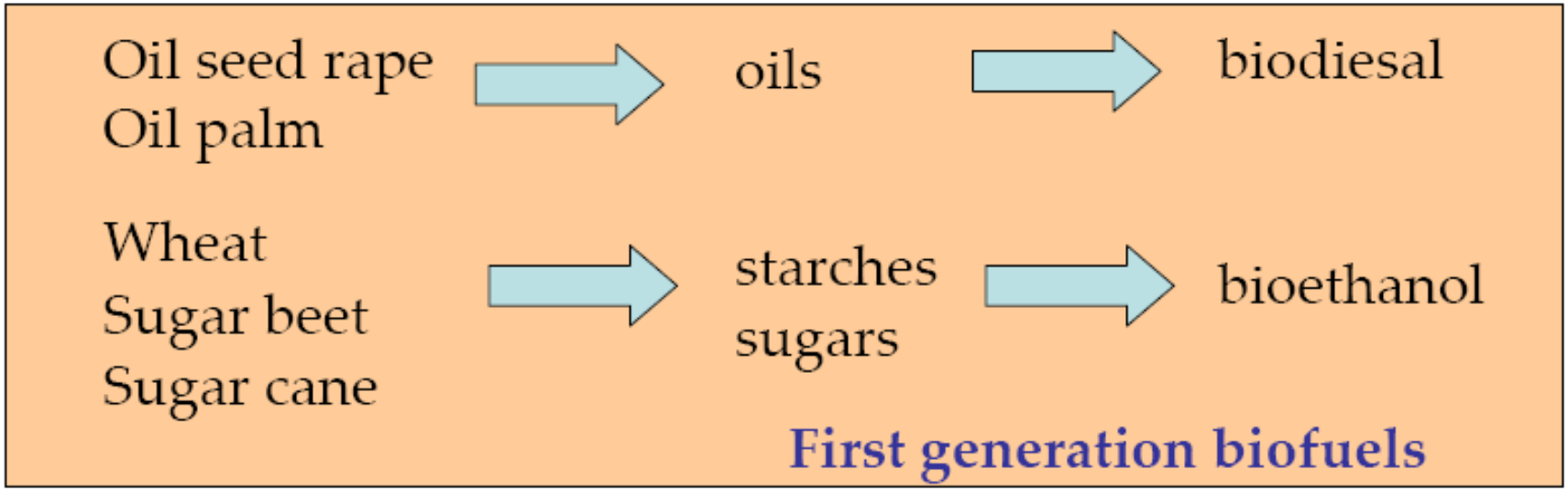
  (In terms of economic efficiency, climate change, world hunger, trade and the environment)
- What are challenges for the future?

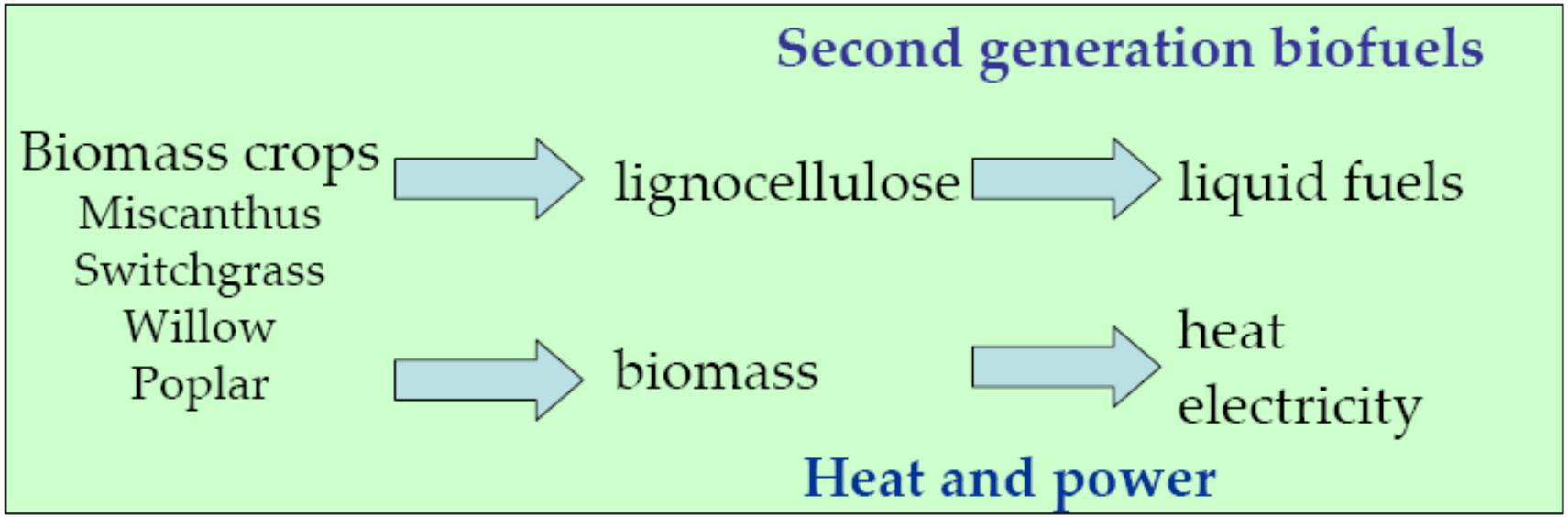
Some definitions

- **Bioenergy** is energy of biological origin, derived from **biomass**, such as fuelwood, livestock manure, municipal waste, energy crops
- **Biofuels** are fuels produced from biomass, usually of agricultural origin
  - Bioethanol
  - Biodiesel
  - Biogas
- **Energy crops** are crops specifically cultivated to provide bioenergy, mainly biofuels but also (miscanthus, short rotation coppice, eucalyptus) other forms of energy

Source: Karp, Rothamsted Research, 2007

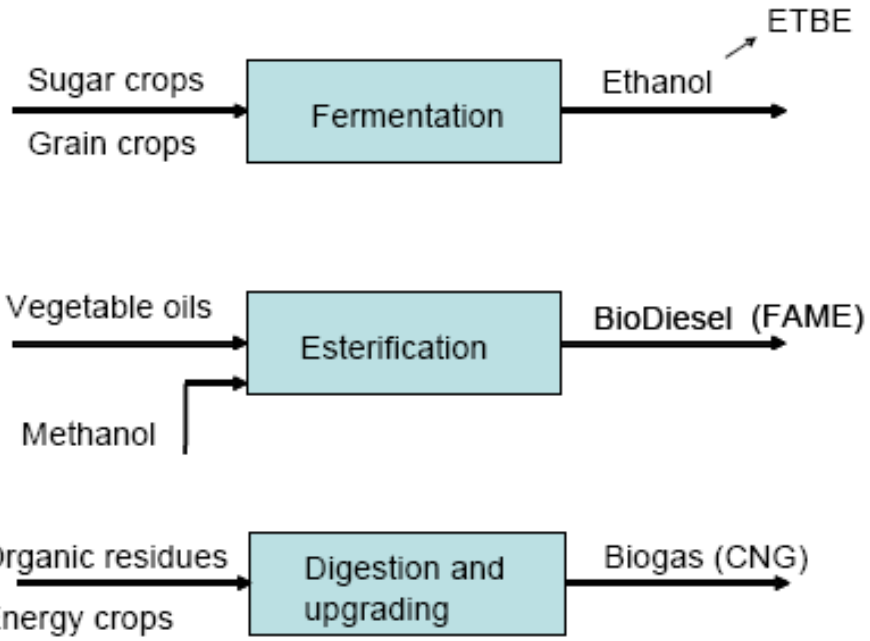
Bioenergy crops



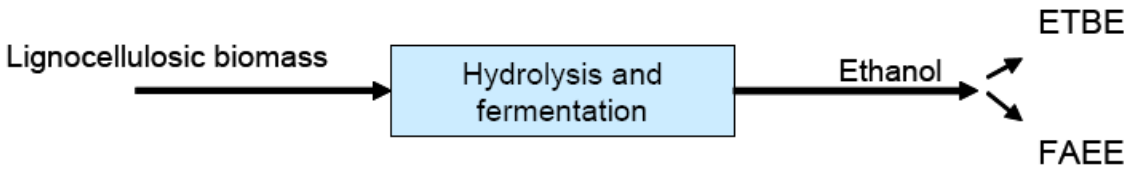


Biofuel transformation processes

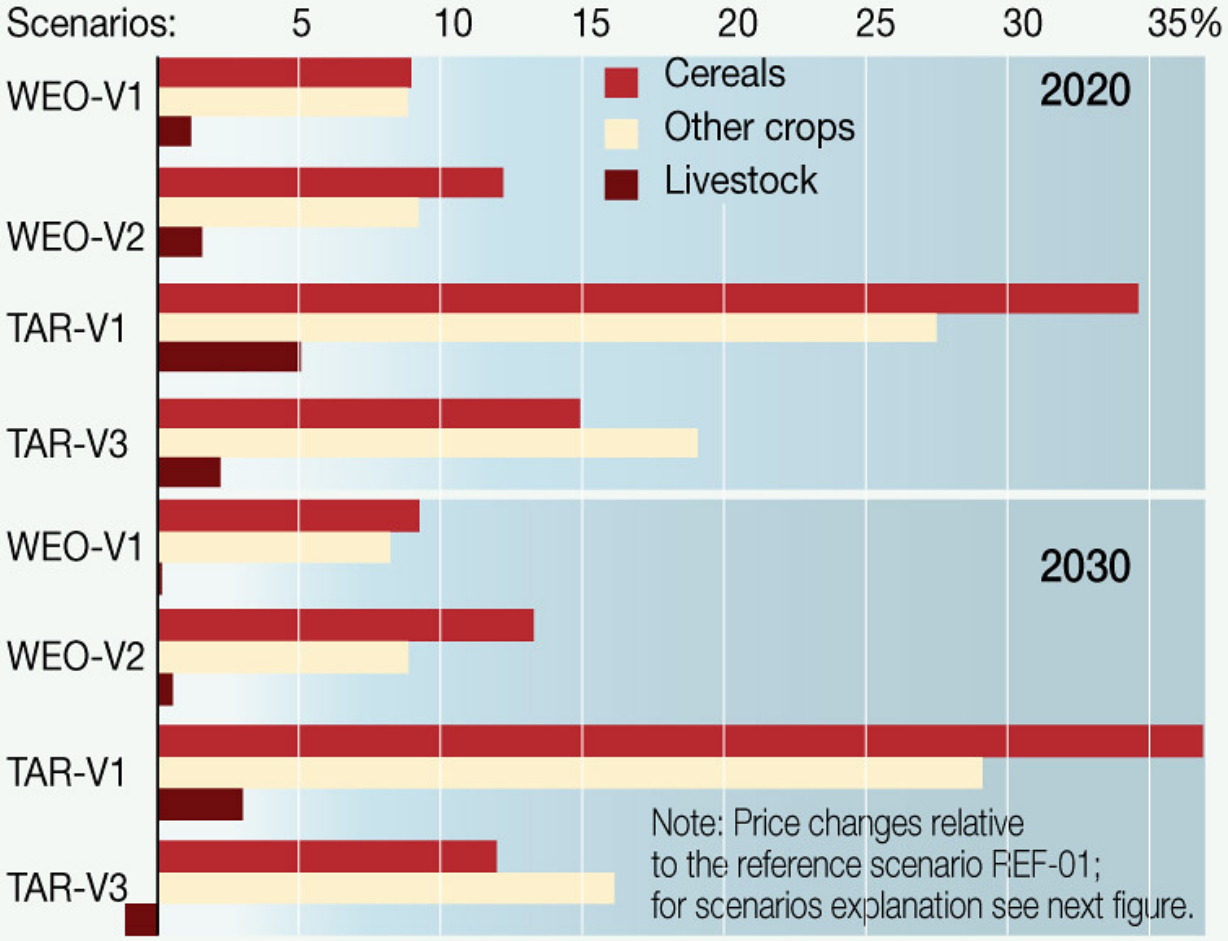
First generation



Second generation



Impacts of first-generation biofuels on agricultural prices

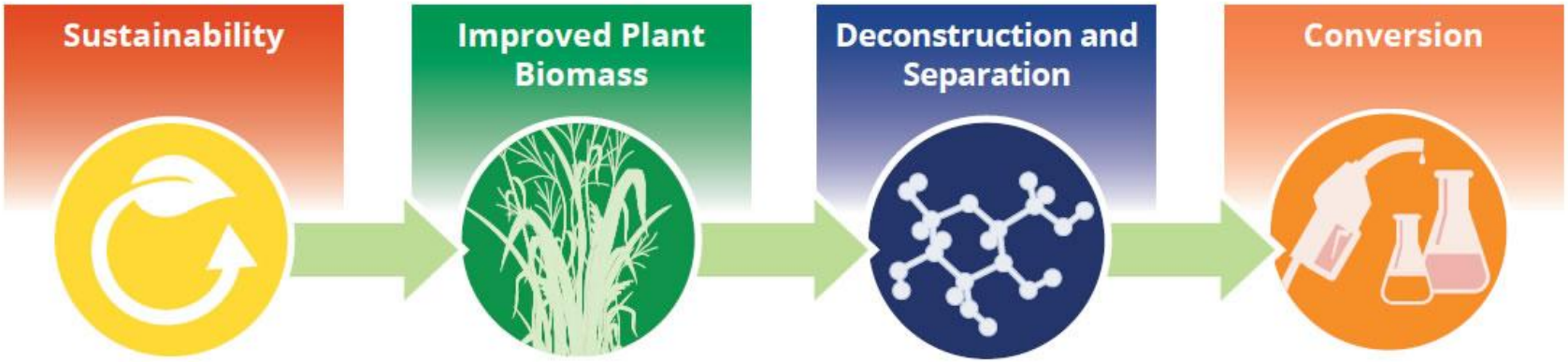


Source: OFID, *Biofuels and Food Security*, 2009.

Biofuel uses

- Bioethanol
  - Used as neat ethanol (E95, blend of 95% ethanol and 5% water)
  - Used as E85 (85% volume ethanol with petrol) in flex-fuel vehicles
  - Used as blend smaller than 5% volume (E5) in ordinary petrol or as its derivative ETBE
- Biodiesel
  - Current maximum 5% in diesel blends, otherwise can only be used in modified diesel engines
- Current 5.75% EU target cannot be met with ordinary blends of petrol and diesel
  - Need for separate infrastructure (pumps, storage, delivery for E85 and biodiesel or pure plant oil)

From Biomass to Advanced Biofuels and Bioproducts



Sustainability

Produce biomass for biofuels and bioproducts with minimal to positive impacts on the environment.

Biomass Development

Develop crops with cell walls optimized for deconstruction and conversion to biofuels and bioproducts.

Biomass Breakdown

Improve enzymes and microbes that break down biomass into sugars and lignin.

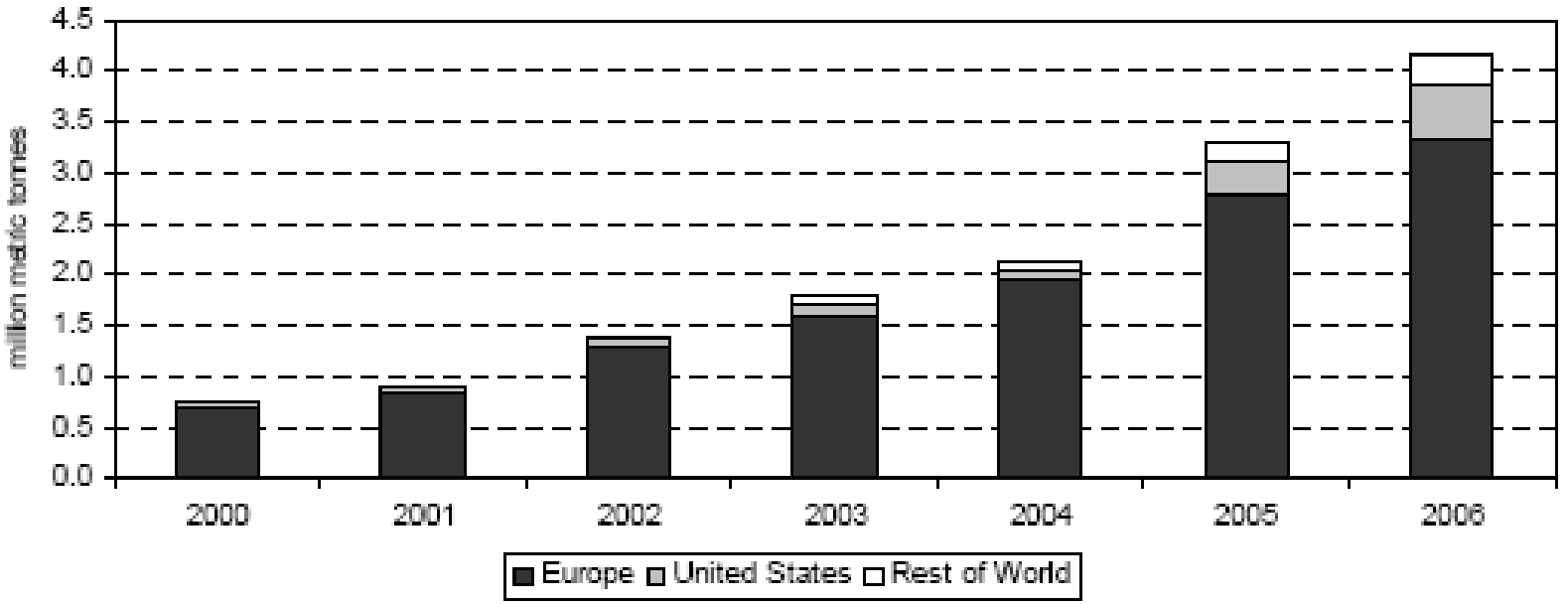
Biofuel and Bioproduct Synthesis

Engineer metabolic pathways in microbes to produce biofuels and bioproducts.

Production and trade trends

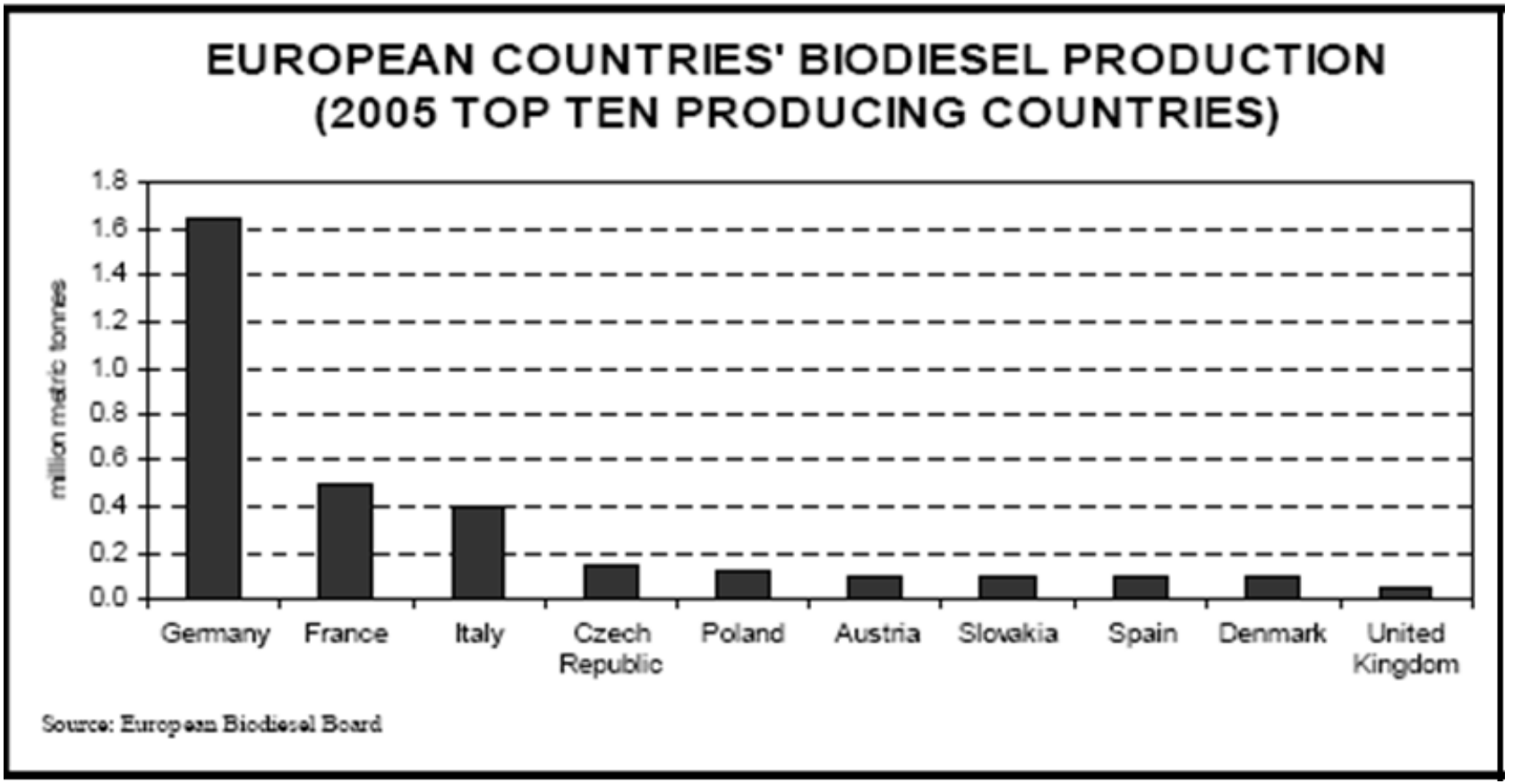
- Brazil (sugar) and the US (maize) are the leading producers of ethanol
- EU (esp. Germany) is leading producer of biodiesel (rapeseed) although production in the US (soybean) is rising
- Malaysia and Indonesia are increasing production of biodiesel from palm oil
- Very limited trade in biofuels to date, mainly some Brazilian bioethanol to EU

SHARES OF WORLD BIODIESEL PRODUCTION (2000-2006)



Source: European Biodiesel Board


biodiesel


EUROPEAN COUNTRIES' BIODIESEL PRODUCTION
(2005 TOP TEN PRODUCING COUNTRIES)
million metric tonnes
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Germany
France
Italy
Czech Republic
Poland
Austria
Slovakia
Spain
Denmark
United Kingdom
Source: European Biodiesel Board

I. Viability of biofuel production

Economics of biofuel production

- The rise in oil prices is the most important factor boosting the competitiveness of alternative fuels, including biofuels.
- Feedstock costs are the most significant cost of biofuel production, 80% for EU biodiesel from rapeseed.
- Energy is also a major cost component, up to 20% of biofuel operating costs in some countries.
- The sale of byproducts, such as dried distillers' grains, also contributes to a biofuel plant's profitability.
- The ratio of crude oil prices to feedstock prices offers a simple indicator of the competitiveness of biofuel made from various feedstocks.


BIOFUEL

Economics of biofuel production

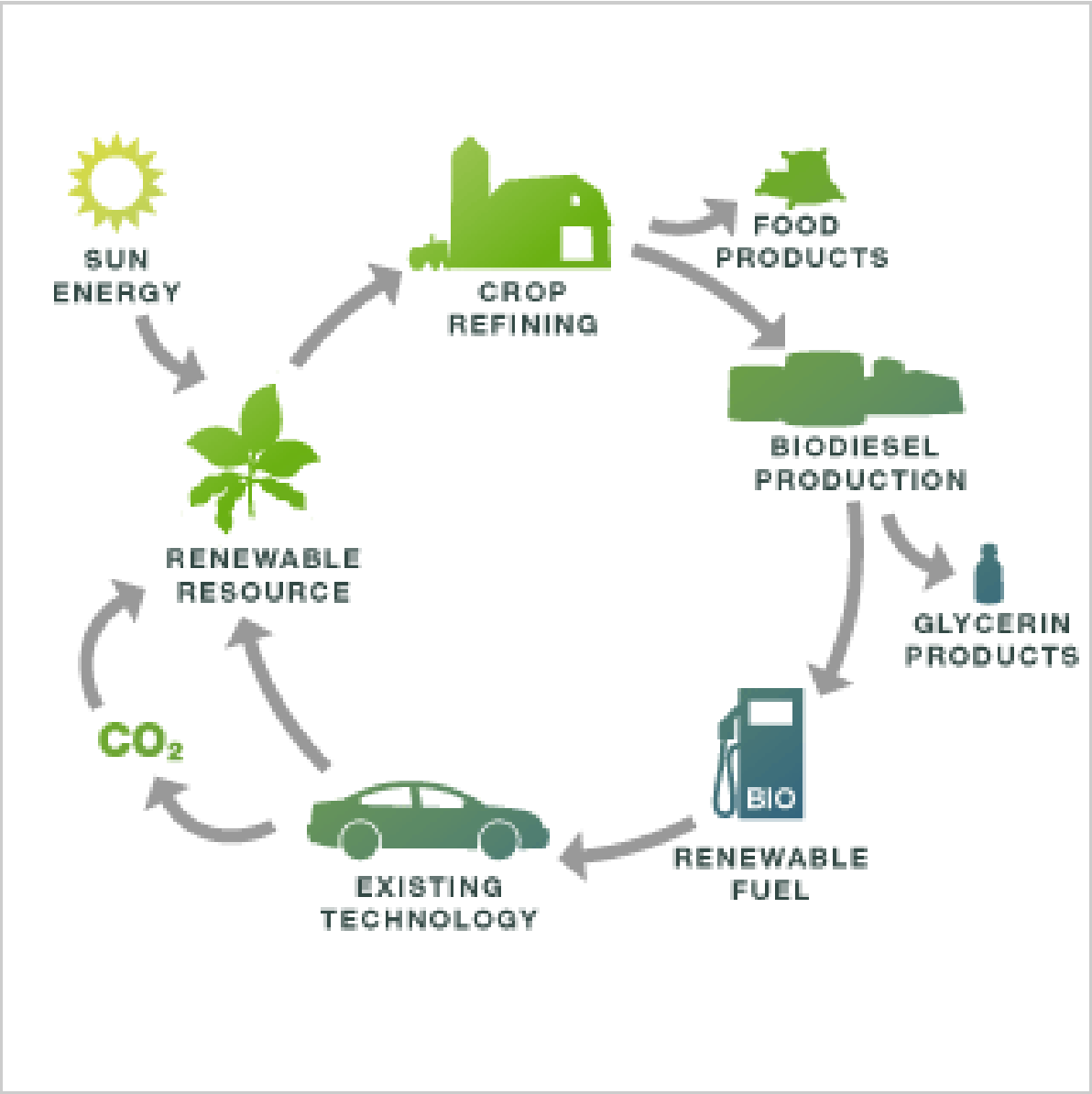
- Higher crude oil prices make competitive production more likely
- Increased biofuel production as well as higher energy costs will push up feedstock costs
- As production grows, the market contribution of by-products may diminish as outlets become satiated

II. Policies to support biofuels

Instruments for supporting biofuels

- biofuel blending obligations
- excise duty exemptions
- tariff protection
- crop (feedstock) subsidies
- research support
- development and investment supports
- fuel standards

Advantages


SUN ENERGY
CROP REFINING
FOOD PRODUCTS
BIODIESEL PRODUCTION
GLYCERIN PRODUCTS
BIO
RENEWABLE FUEL
EXISTING TECHNOLOGY
CO_2
RENEWABLE RESOURCE

EU objectives for biofuels

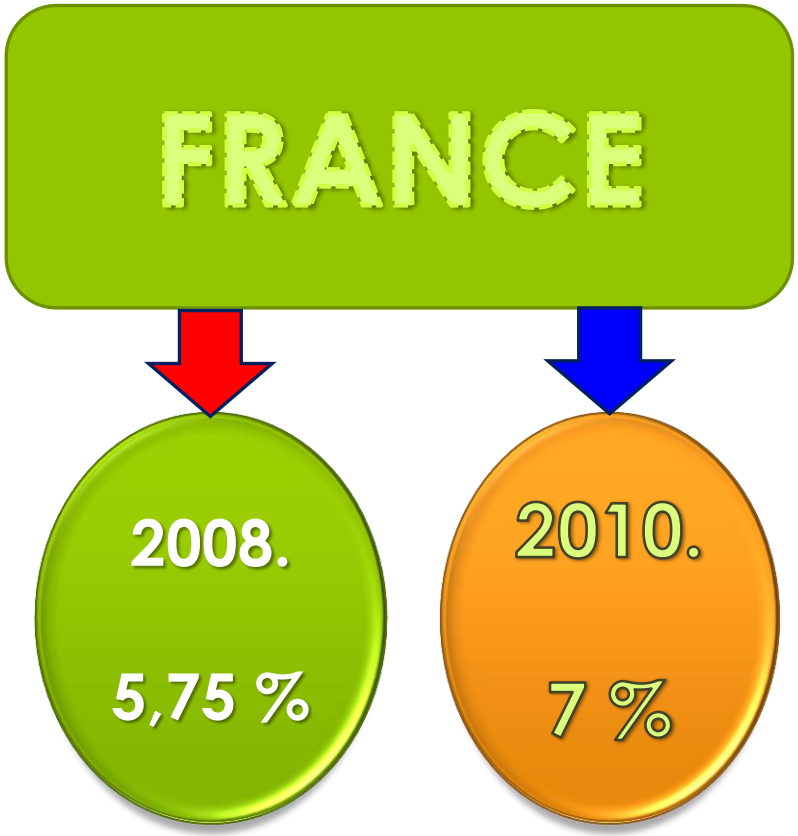
- 1997
  - 12% renewable energy target by 2010
- 2003 Biofuels use directive
  - 2% target for biofuels in transport fuels by 2005 (1% achieved); 5.75% by 2010
  - Not mandatory, but annual reports required
- 2003 Energy taxation directive
  - Allowed MS to grant tax reductions and exemptions on biofuels
- 2007 "Energy Policy for Europe" package
  - Mandatory target of 10% of biofuels in transport fuels by 2020

BIOFUELS

NATIONAL INDICATIVE TARGETS FOR THE SHARE OF BIOFUELS, 2006-2010

	2006	2007	2008	2009	2010
	.....	.....	percent	.....	.....
Austria	2.50	4.30	5.75	5.75	5.75
Belgium	2.75	3.50	4.25	5.00	5.75
Cyprus					
Czech Republic	1.78	1.63	2.45	2.71	3.27
Denmark	0.10				
Estonia	2.00				5.75
Finland					
France			5.75		7.00
Germany	2.00				5.75
Greece	2.50	3.00	4.00	5.00	5.75
Hungary					5.75
Ireland	1.14	1.75	2.24		
Italy	2.00	2.00	3.00	4.00	5.00
Latvia	2.75	3.5	4.25	5.00	5.75
Lithuania					5.75
Luxembourg	2.75				5.75
Malta					
The Netherlands	2.00	2.00			5.75
Poland	1.50	2.30	2.80	2.90	5.75
Portugal	2.00	3.00	5.75	5.75	5.75
Slovakia	2.50	3.20	4.00	4.90	5.75
Slovenia	1.20	2.00	3.00	4.00	5.00
Spain					
Sweden					5.75
UK			2.00	2.80	3.50
EU					**5.75**

Source: 2006 Biofuels Progress Report



EU supports for biofuels

- EU has authorised MS to grant tax relief on biofuels
- Energy crop payment of €45/ha introduced in 2003, but limited to 2 million hectares on non setaside land
- Energy crops can also be grown on setaside land
- High tariffs on ethanol (up to 63% AVE) but with preferential access for many developing countries
- Tariffs on biodiesel are low (6.5%) and even lower (0-5%) on oilseeds and vegetable oils for industrial uses
- Relatively limited EU interventions has encouraged MS to implement their own action plans and instruments

Impacts on land use and agricultural markets

EU land constraints

- EU biofuel directive: 5.75% of EU fuel supply by end 2010
- 24 mio t biofuels to reply about 18.6 mio t of fossil fuels (due to lower energy content)
- European Commission estimates
  - 16-18 mio ha needed if all biofuels feedstocks grown in EU
  - Which is about 17% of total arable area: 103.6 mio ha
- Area reserve:
  - About 2.8 mio ha obligatory set aside not yet grown with biofuel crops
  - 3 mio ha arable land currently not used.

Source: Banse, 2007; see also Bamière et al. 2007

Impact on agricultural markets

- How large will be potential demand from energy markets for agricultural products? Will it be large enough to reverse the secular decline in real food prices?
- While large technical potential for biomass exists, food prices cannot rise faster than energy prices in the longer term

Floor and ceiling price effects

- Agricultural prices always affected by energy prices
- But as fossil fuel energy prices reach or exceed the energy equivalent of agricultural products, energy market creates demand for agricultural products
- Higher energy prices now affecting **output prices**
- OECD estimates show that the effect of oil prices on production costs is comparatively much stronger than that on increased demand for biofuel, but results are sensitive to oil price.

Floor and ceiling price effects

- Given large (elastic) demand from energy market with competitive agricultural feedstocks, energy market creates a floor price for agricultural products
- Fossil fuel prices also create a ceiling for competitive feedstocks whose price cannot rise faster than energy prices without pricing themselves out of the energy market

Differential price effects on agricultural markets

- Food price increases will be neither **open-ended** nor **uniform**
- Agricultural products will be affected differently depending on
  - Their break even or parity point
  - Balance of energy and protein content
  - Bioenergy demand is limited to the energy content of feedstocks, creating additional supply of protein-rich by-products
  - Protein prices are likely to rise less rapidly than energy prices and could even fall in absolute terms

Differential price effects of different bioenergy scenarios

	An additional 10 million tonnes of ...				
	Sugar	Maize	Sugar and Maize	Soybeans and Maize	Sugar, Maize and Soybeans
Corresponding energy [biofuels]	0.195 EJ	0.087 EJ	0.282 EJ	0.167 EJ	0.349 EJ
Commodity	... used for biofuels would change international prices (percent) in the long-run by :				
Sugar	+9.8	+1.1	+11.3	+2.3	+13.8
Maize	+0.4	+2.8	+3.4	+4.0	+4.2
Vegetable oils	+0.3	+0.2	+0.2	+7.6	+7.8
Protein	+0.4	-1.2	-1.2	-8.1	-7.6
Wheat	+0.4	+0.6	+0.9	+1.8	+2.0
Rice	+0.5	+1.0	+1.2	+1.1	+1.4
Beef	+0.0	+0.2	+0.2	+0.4	+0.4
Poultry	+0.0	-0.4	-0.4	-2.1	-2.0

Source: Schmidhuber 2006

Agricultural market effects

- With greater share of maize and other markets characterised by inelastic demand (e.g. through biofuel mandates) which is also tied to crude oil prices, together with smaller stocks, increased agricultural crop price and market **volatility** can be expected

Food price effects

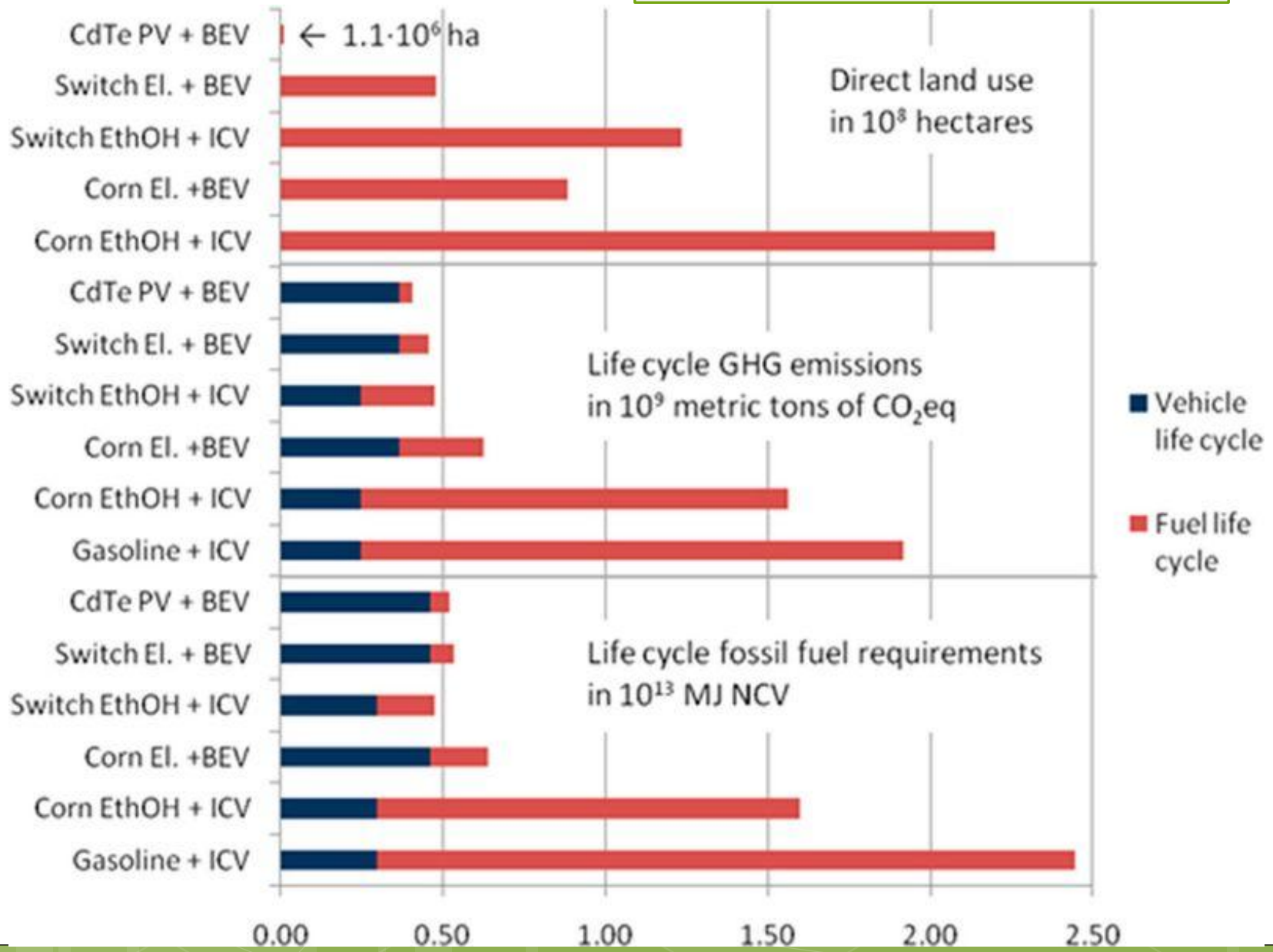
- First round impact approximated by (change in price of raw ingredient) x (share of food item price represented by that ingredient)

Example

- Maize is 38% of cost of producing pigmeat, and pigmeat is 28% of final retail price of pork
  - Suppose ethanol demand increases maize price by 50%
  - Price of pork would then increase by 5.3%
  - Overall, doubling of feed grain and oilseed prices would increase food prices by less than 4%

Biofuels are an important element of the EU's renewable energy policy, which is helping Europe keep its leadership role in in the clean energy transition and in meeting the goals set by the Paris Agreement.

Solar-Electric Cars vs Biofuel Cars



Renault extends BioFuel model range

"REDII" or the "Directive"

The new Renewable Energy Directive

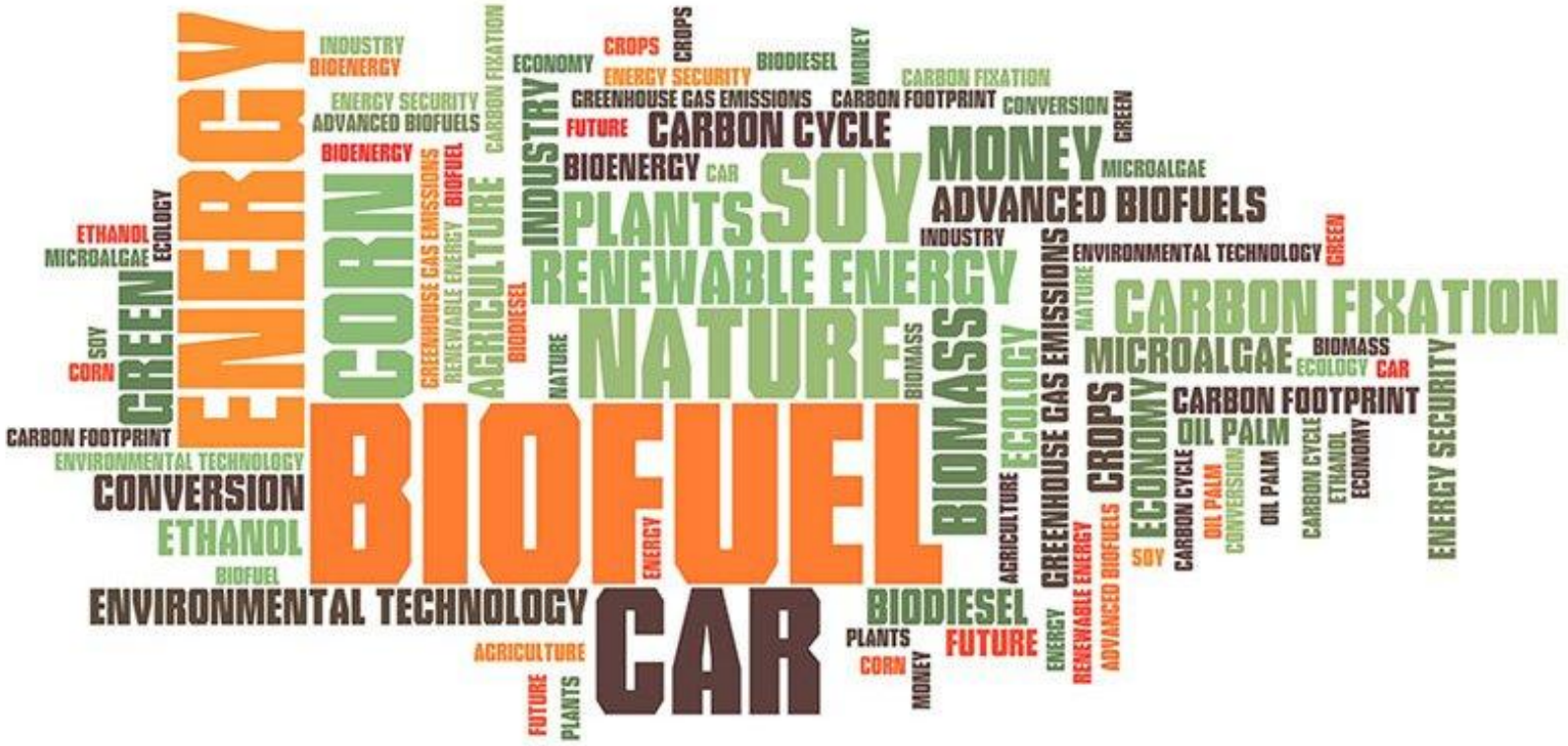
24 December 2018

This Directive promotes the development of renewable energy in the next decade through an EU - wide renewable energy binding target of at least 32% by 2030, to be achieved collectively by Member States. In order to do so, the Directive includes a number of sectoral measures promoting further deployment of renewables in the electricity, heating and cooling and transport sectors, with the overall aim of contributing to reducing greenhouse gas (GHG) emissions, improving energy security, reinforcing Europe's technological and industrial leadership in renewable energy and creating jobs and growth.

Growing global demand for food and feed crops is requiring the agricultural sector to constantly increase production. This is achieved by both increasing yields and by an expansion of the agricultural area. If the latter takes place into land with high-carbon stock or highly biodiverse habitats, this process can result in negative ILUC impacts.

Against this background, REDII limits the contribution of conventional biofuels, bioliquids and biomass fuels consumed in transport towards the Union 2030 renewable energy target. In addition, the contribution of high ILUC-risk biofuels, bioliquids and biomass fuels will be limited at 2019 levels starting from 2020, and then gradually reduced to zero between 2023 and 2030 at the latest.

https://ec.europa.eu/energy/sites/ener/files/documents/report.pdf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PLANTS
RENEWABLE ENERGY
CARBON FIXATION
ADVANCED BIOFUELS
CARBON CYCLE
BIOENERGY
INDUSTRY
AGRICULTURE
BIOMASS
GREEN
ENVIRONMENTAL TECHNOLOGY
CONVERSION
ETHANOL
MICROALGAE
CROPS
ECONOMY
CARBON FOOTPRINT
OIL PALM
BIODIESEL
FUTURE
ENERGY SECURITY
GREENHOUSE GAS EMISSIONS
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