2. National IEA Bioenergy Task 39, “Liquid Biofuels” Workshop

Vienna,
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Biofuel production potentials in Europe – Sustainable use of cultivated land and pastures

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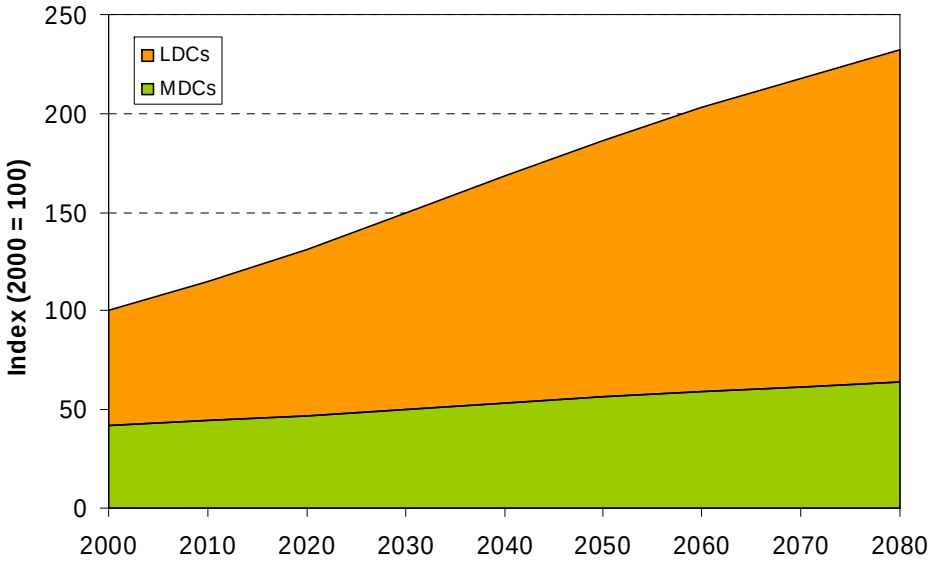
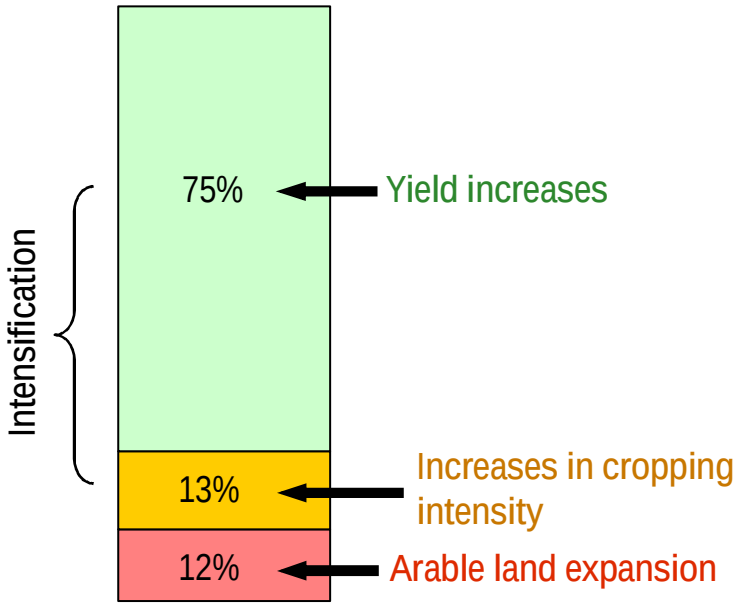
Food and Agriculture Outlook

Growth of:	2000-2050
Arable land	12%
Cereal production	69%
Ruminant meat	73%
Other meat	85%
Agriculture	86%

Index of agricultural production, IIASA A2r scenario, 2000-2080

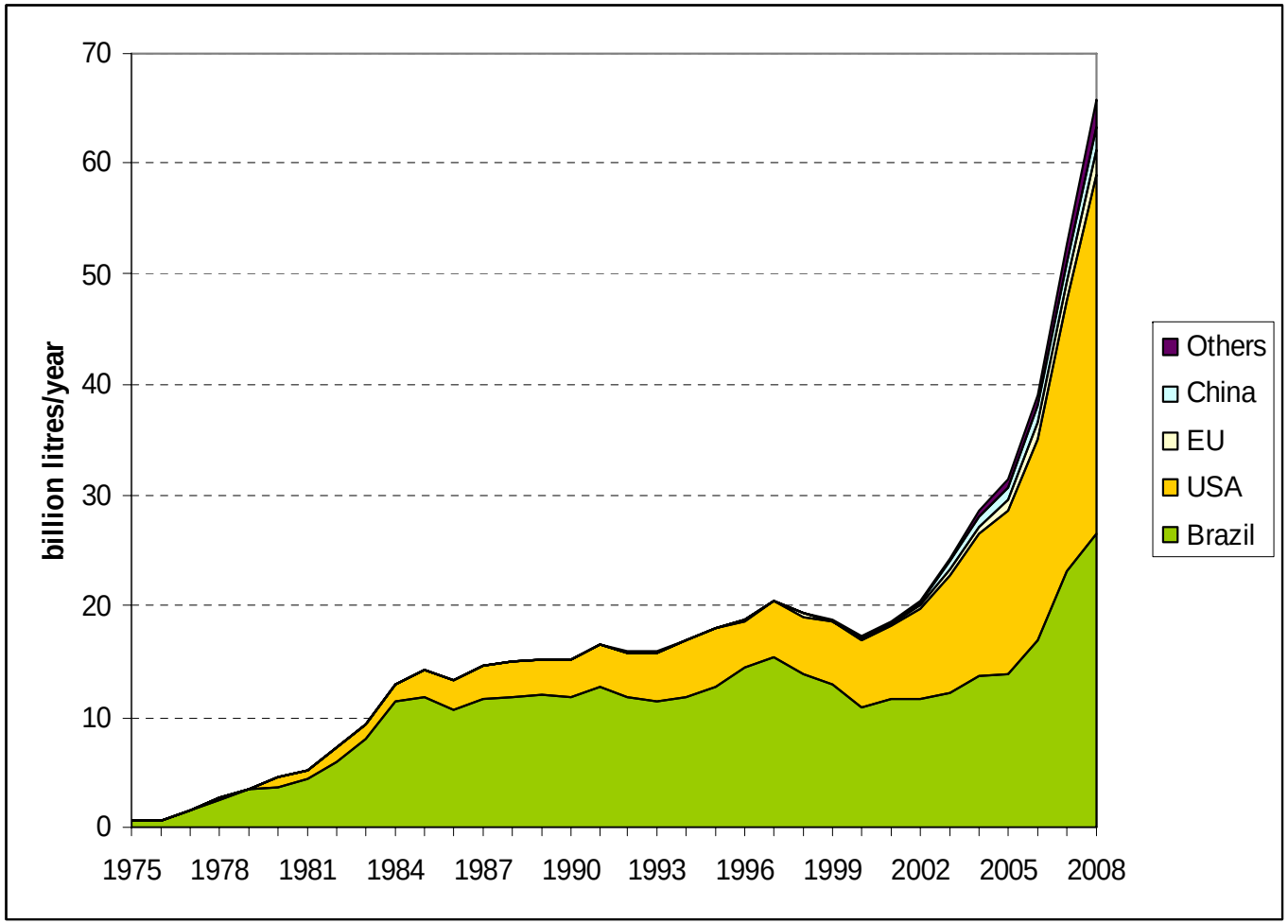


Sources of growth in agricultural production, Scenario A2r, 2000-2050



Source: World Food System simulations of IIASA GGI scenarios, Fischer et al. (2005).

World fuel ethanol production (billion liters/year)



Source: F.O. Lucht World Ethanol & Biofuels Report, October 2007 and May 2008.

Bio-energy Production & Food Security & Land Competition:

- The role of bio-energy has been strongly enhanced by its consideration in the climate change debate, as well as opportunities it may create for rural development and improved energy security.
- Land use competition with food and feed production is considered a potential key barrier to exploiting the bio-energy production potential.

Current LUC projects:

- Global Assessment of Bio-energy Potentials
- Renewable Fuels for a Sustainable Europe (REFUEL)
- Effective and Low-disturbing Bio-fuel Policies (ELOBIO)

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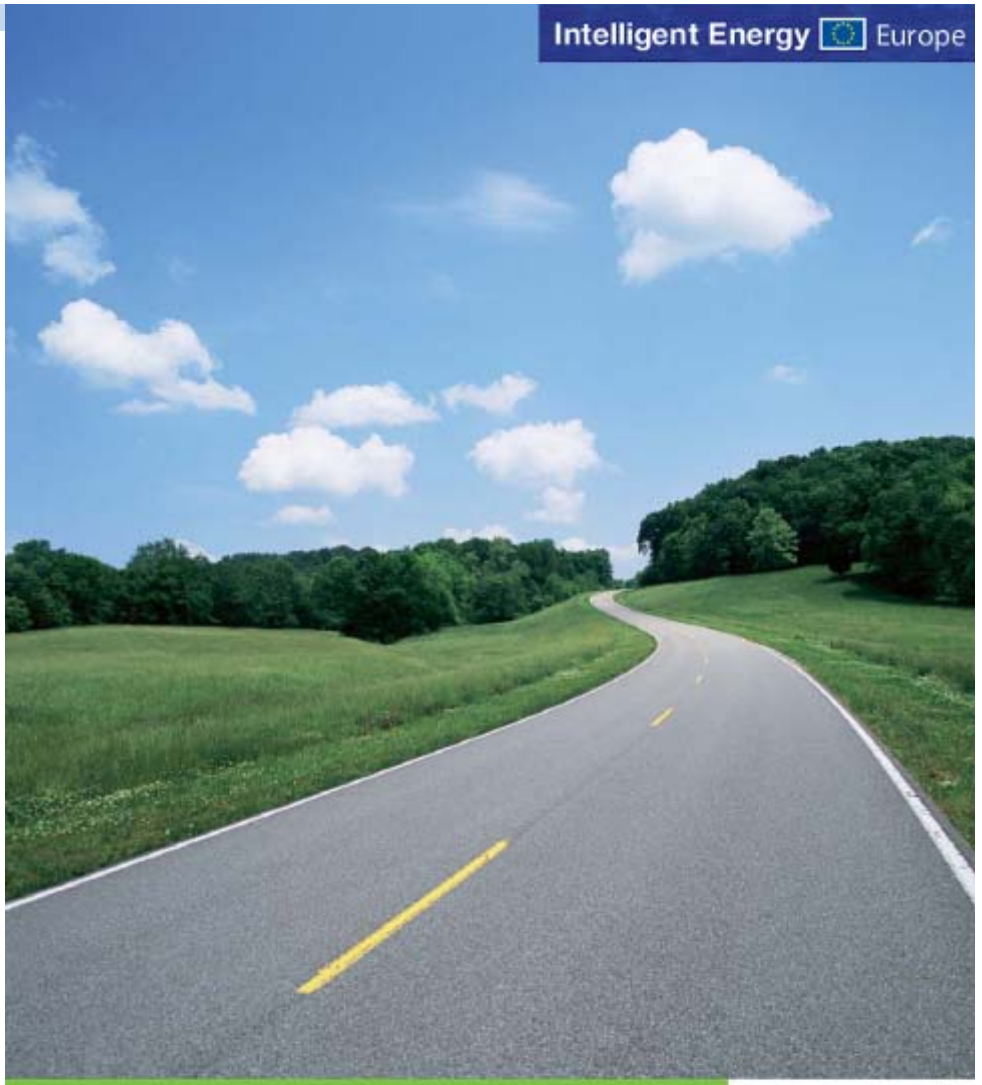


Eyes on the track, Mind on the horizon

From inconvenient rapeseed to clean wood: A European road map for biofuels

refuel

REFUEL, main objectives

To develop an ambitious, yet realistic road map for an effective deployment of biofuels until 2030 in the EU25+

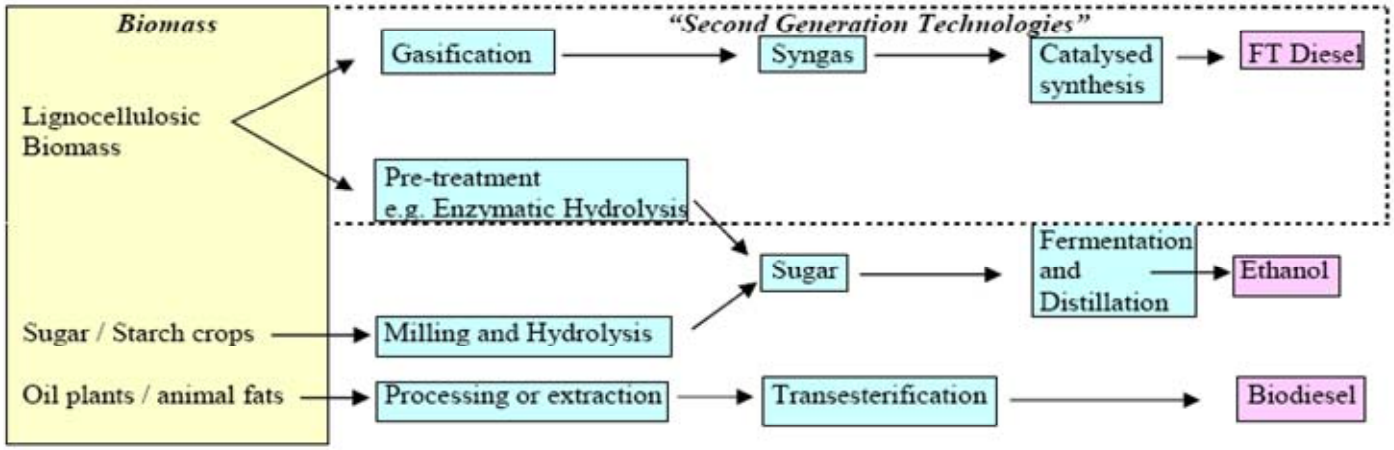
- Land availability
- Feedstock potentials
- (relative) costs of biofuels
- Impacts
- Strategy and policy issues
- Implementation issues

Bio-fuel Feedstocks

Feedstock groups:

- Oil crops
  Rapeseed; Sunflower; Soybean; Oilpalm; Jatropha
- Sugar crops
  Sugarcane; Sugar beet; Sweet sorghum
- Starch crops
  Wheat; Rye; Triticale; Maize; Sorghum; Cassava
- Herbaceous lignocellulosic plants
  Miscanthus; Switchgrass; Reed canary grass
- Woody lignocellulosic plants
  Poplar; Willow; Eucalyptus

Figure 1. Fuel production pathways



Source: adapted from BMU (2006) and Hamelinck and Faaij (2006)

Conceptual framework of Agro-ecological Zones methodology

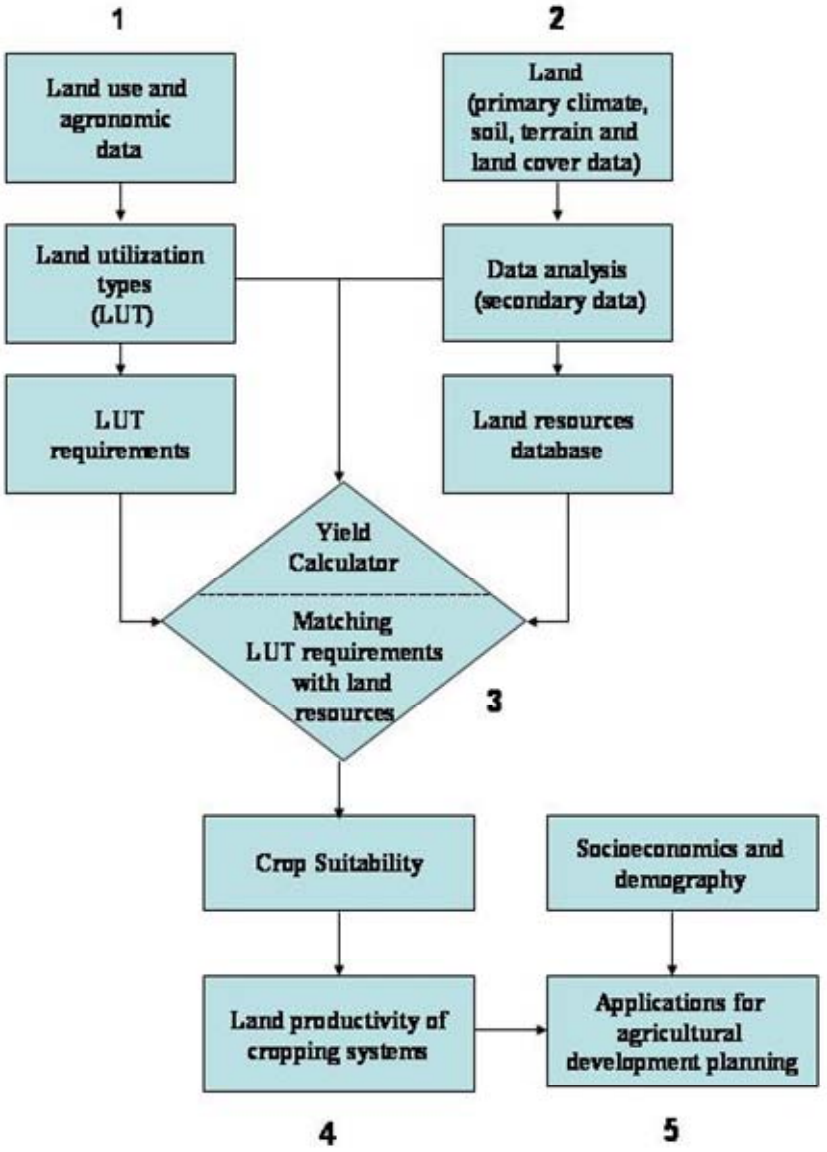
1. Land Utilization types (LUTs) - Selected agricultural production systems with defined input and management relationships, and crop-specific environmental requirements and adaptability characteristics. These are termed Land Utilization Types (LUT);

2. Land Resources database - Geo-referenced climate, soil and terrain data which are combined into a land resources database;

3. Crop biomass and yield and LUT requirements matching - Procedures for the calculation of potential yields and for matching crop/LUT environmental requirements with the respective environmental characteristics contained in the land resources database, by land unit and grid-cell;

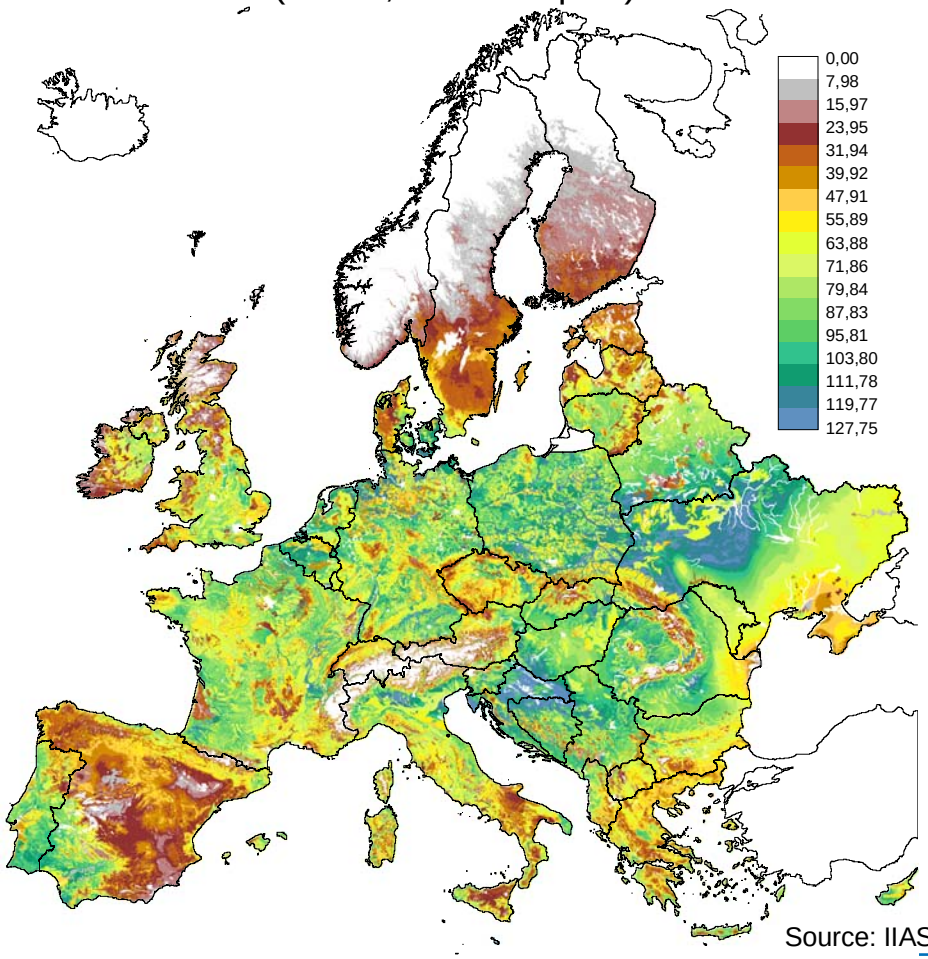
4. Assessments of crop suitability and land productivity, and

5. Applications for agricultural development planning.

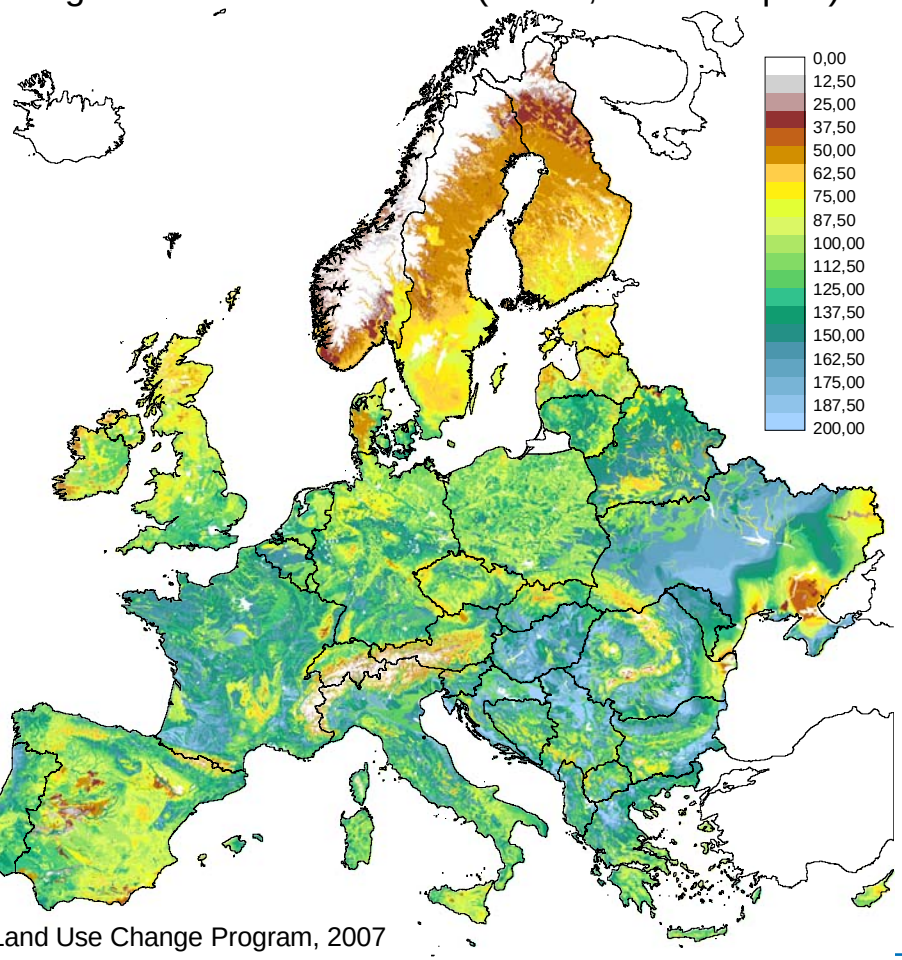


Bio-fuel Feedstock Yield Potential

(a) Attainable energy yields of 1st generation crops (GJ/ha, biofuel equiv.)

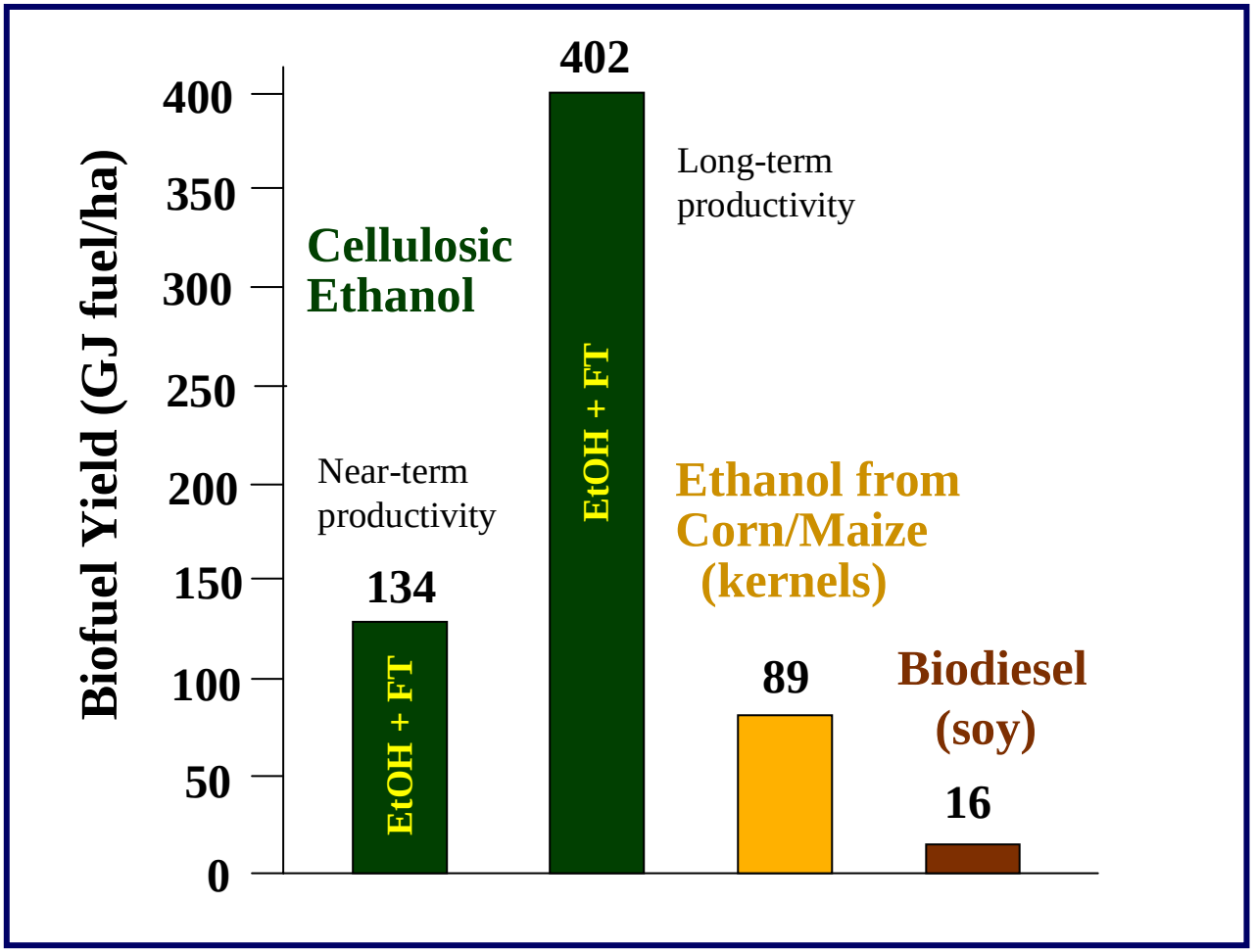


(b) Attainable energy yields of 2nd generation lignocellulosic feedstocks (GJ/ha, biofuel equiv.)



Source: IIASA Land Use Change Program, 2007

Comparative Land Productivity of Biofuel Options

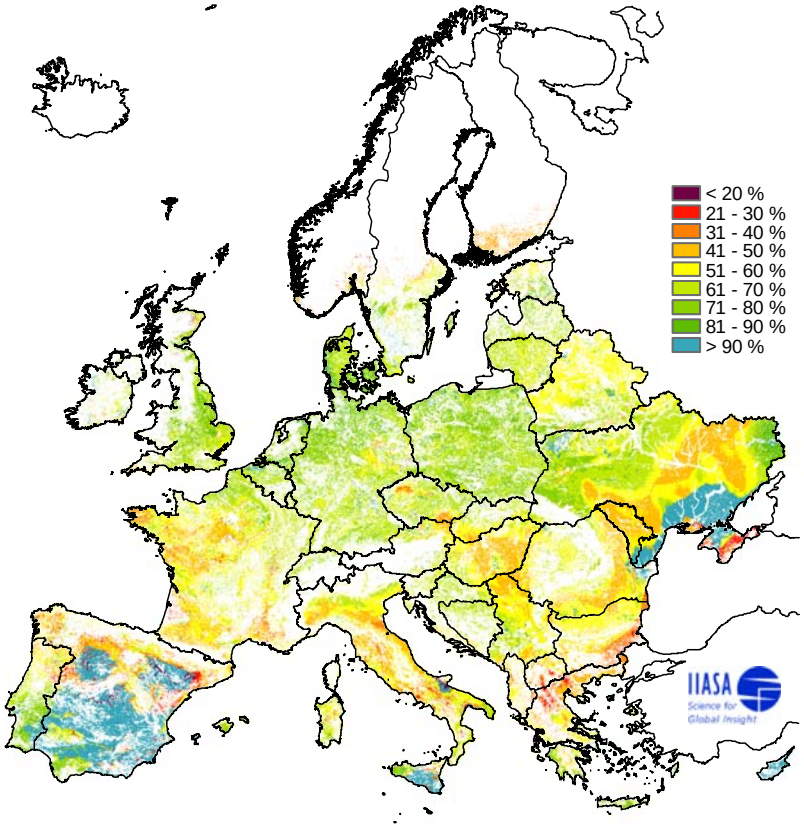


Crop Yields (U.S.)	Fuel Yields
Biomass yield: 5 dry ton/acre	Cellulosic ethanol from RBAEF
Corn yield: 160 bushel/acre	Corn ethanol: 2.8 gal/bushel
Soy yield: 42 bushel/acre	Soy oil: 18% of bean (dry basis)
	Biodiesel yield: 0.95 kg/kg soy oil

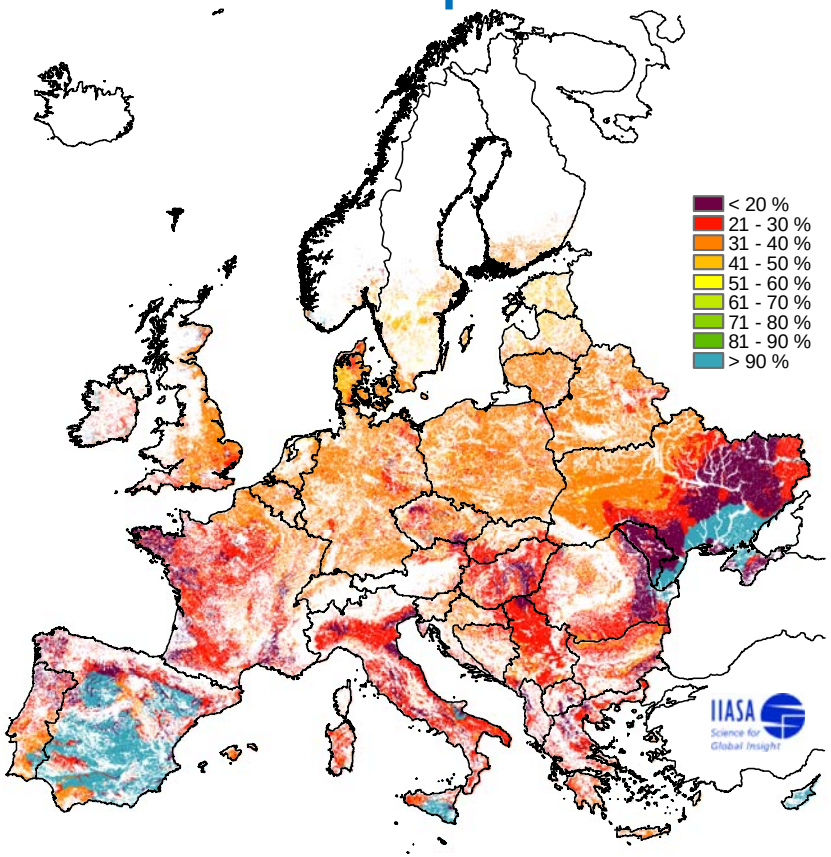
Land use efficiency of 1st compared to 2nd genêration feedstocks

Ratio of energy yields (biofuel equ.)

1st / 2nd



Oil crops / 2nd

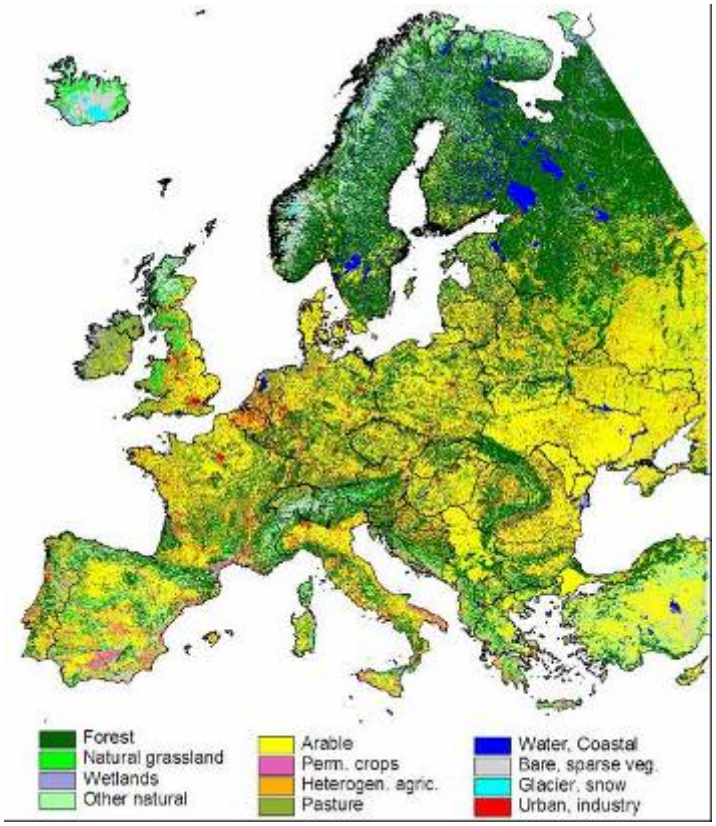


Source: IIASA Land Use Change Program, 2007

Current land use (year 2000)

Available LAND

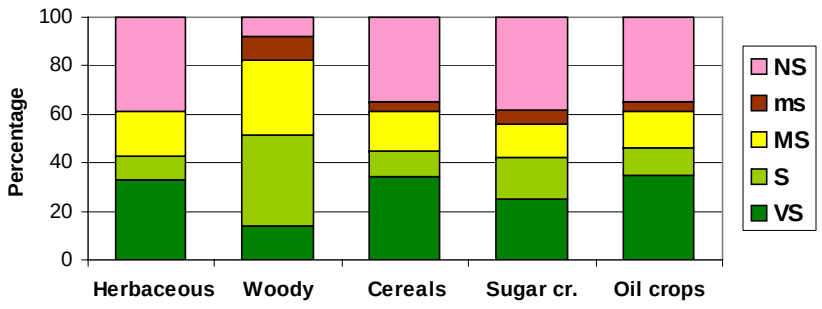
million hectares	**EU15**	**EU12**	**Ukraine**
Total land	**312**	**106**	**60**
CULTIVATED	**84.1**	**44.6**	**33.5**
of which: arable	72.3	42.8	32.5
perm. crops	11.2	1.8	0.8
PASTURE	**51.3**	**15.1**	**7.9**
of which: in feed use	36.0	3.5	3.0
other	15.3	11.6	4.9
FOREST and other wooded land	**125.0**	**34.9**	**9.6**
BUILT-UP and associated land	**22.6**	**6.0**	n.d.
Other	**29.3**	**5.3**	**9.4**

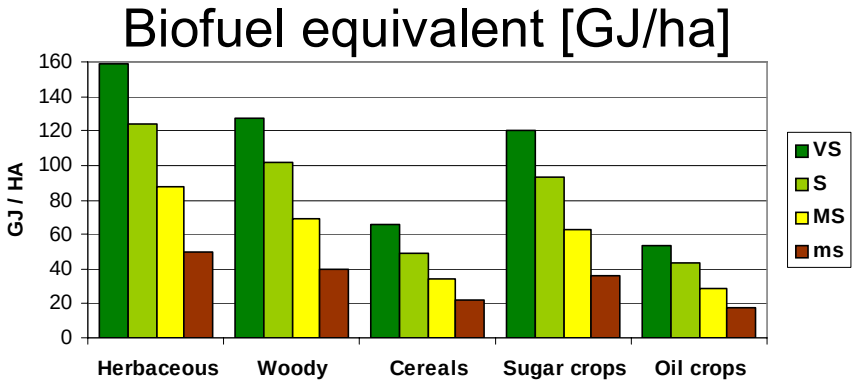


POLAND – Suitability for biofuel feedstock

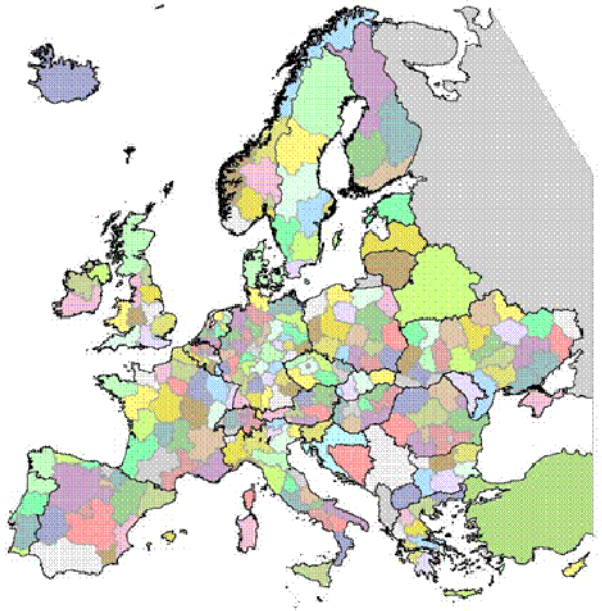
Feedstocks

Suitability index	SUITABILITY distribution of agricultural area (%)					Average **YIELD** (rainfed) by suitability class				
	VS	**S**	**MS**	**mS**	**NS**	**VS**	**S**	**MS**	**mS**	Unit of Yield
Herbaceous	33	10	18	0	39	17.1	13.3	9.4	5.4	ton d.w./ha
Woody	14	37	31	10	7	13.3	10.6	7.2	4.1	ton d.w./ha
Cereals	34	11	16	4	35	8.6	6.5	4.5	2.9	ton d.w./ha
Sugar crops	25	17	14	6	38	8.6	6.7	4.5	2.6	ton sugar/ ha
Oil crops	35	11	15	4	34	1.5	1.2	0.8	0.5	ton oil / ha





Summary: Feedstock assessment



- Detailed resource database available for assessing suitability of alternative biofuel feedstocks;
- CLC2000 land cover grid (at 100 m) used to determine current use of land potentially suitable for biofuel feedstock production;
- Suitability and bio-productivity assessment with AEZ model operating at 1 km resolution database;
- Aggregation of individual feedstock potentials to national or sub-national administrative units by major land cover class;
- Availability of land was assessed assuming (a) scenarios of demographic change and per capita consumption, (b) convergence of yields for WEC and CEEC, and (c) maintaining of current European levels of self-reliance for food and feed.

Land use scenarios – Approach

Available LAND

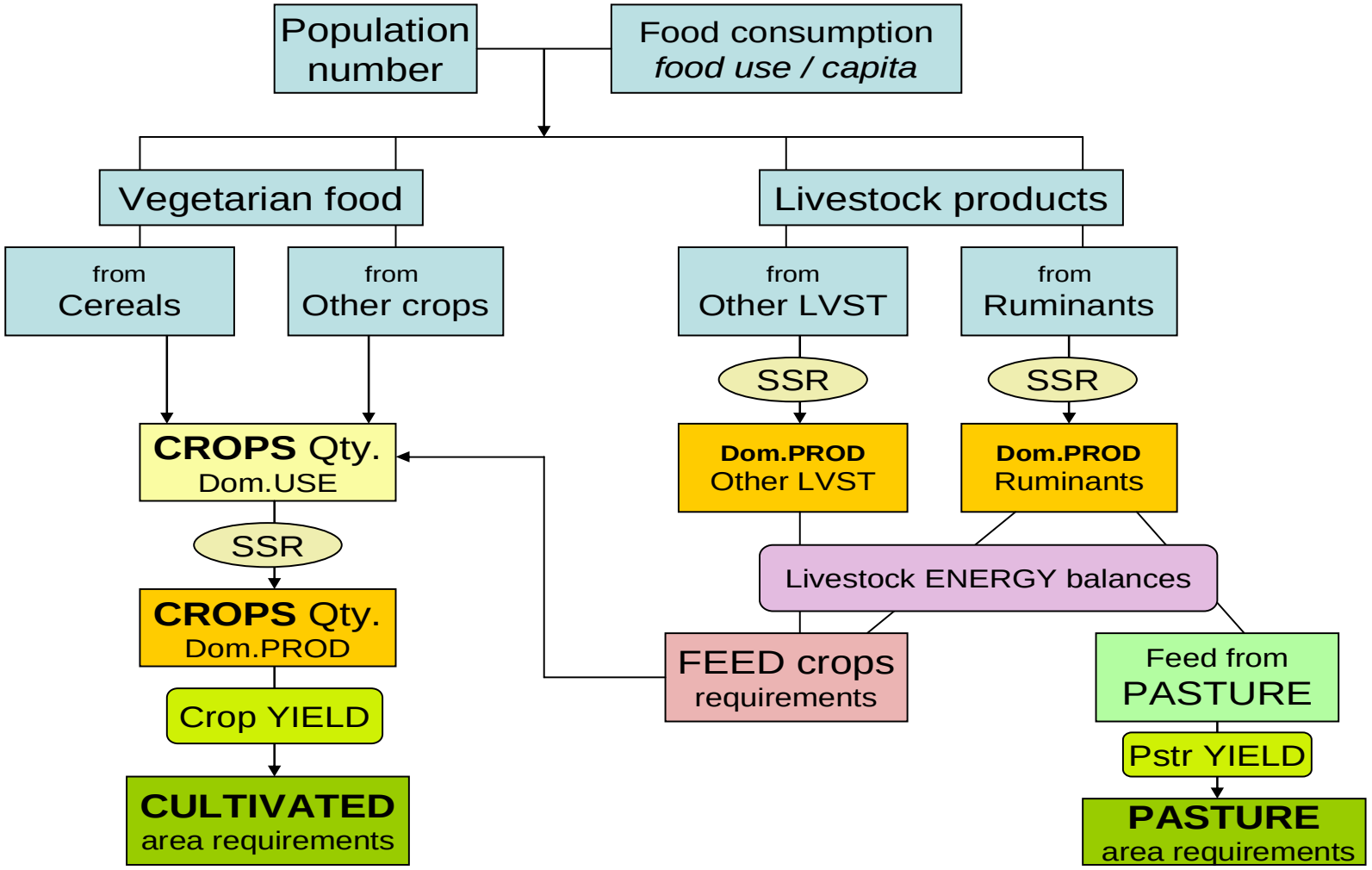
Policy issues:

Competition of energy crops **with food and feed** production is a key issue in the policy debate on expanding biofuel use.

The basic approach is to assess availability of agricultural land in excess of land required for food and feed production:

- Land use model
- Per country
- Year 2000 – 2030
- Relates demand with production
- Scenario dependent productivity increases free up land in the future
- Differentiates arable land and pasture

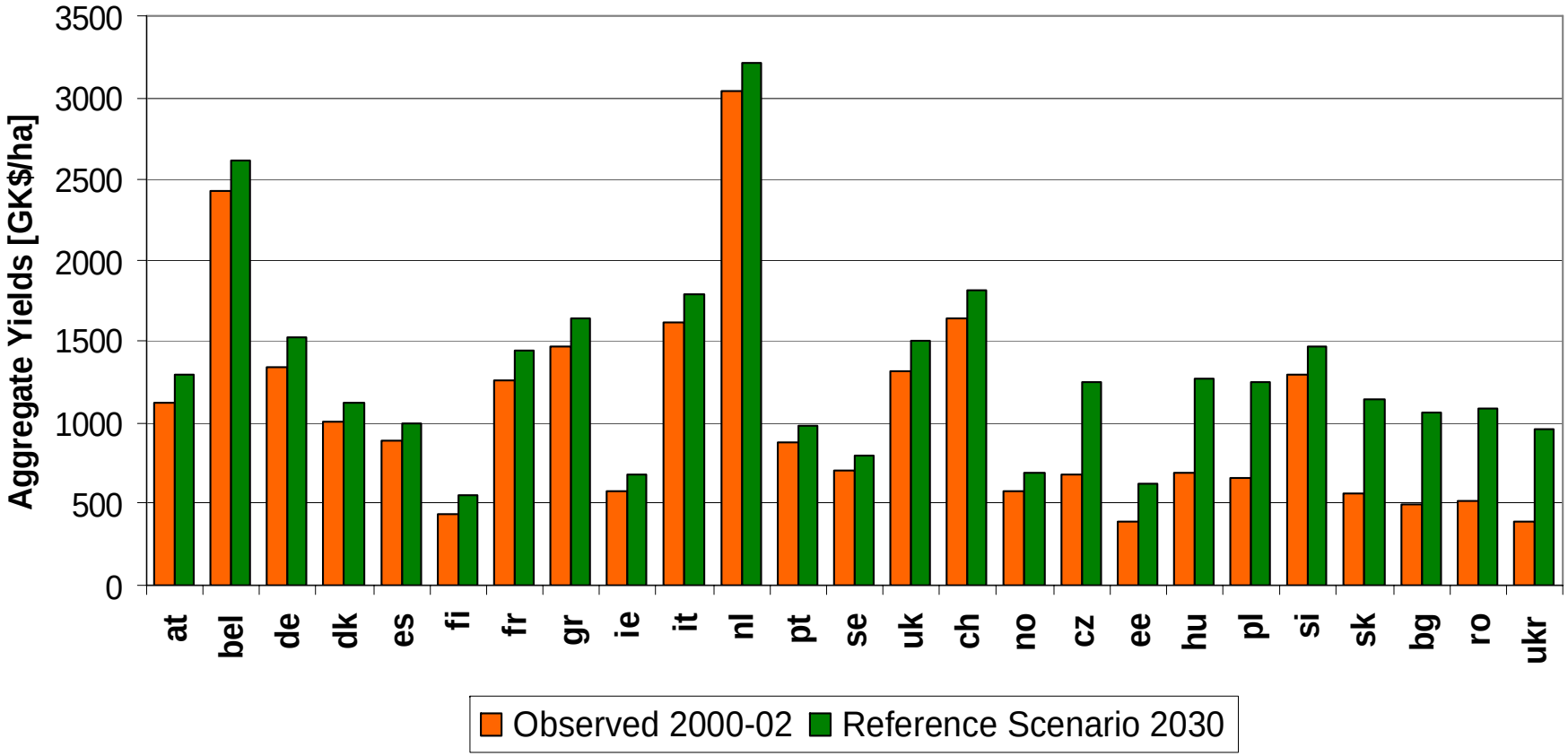
Land use model scheme – 'Food first' paradigm



Land use scenarios - Assumptions

Crop YIELD

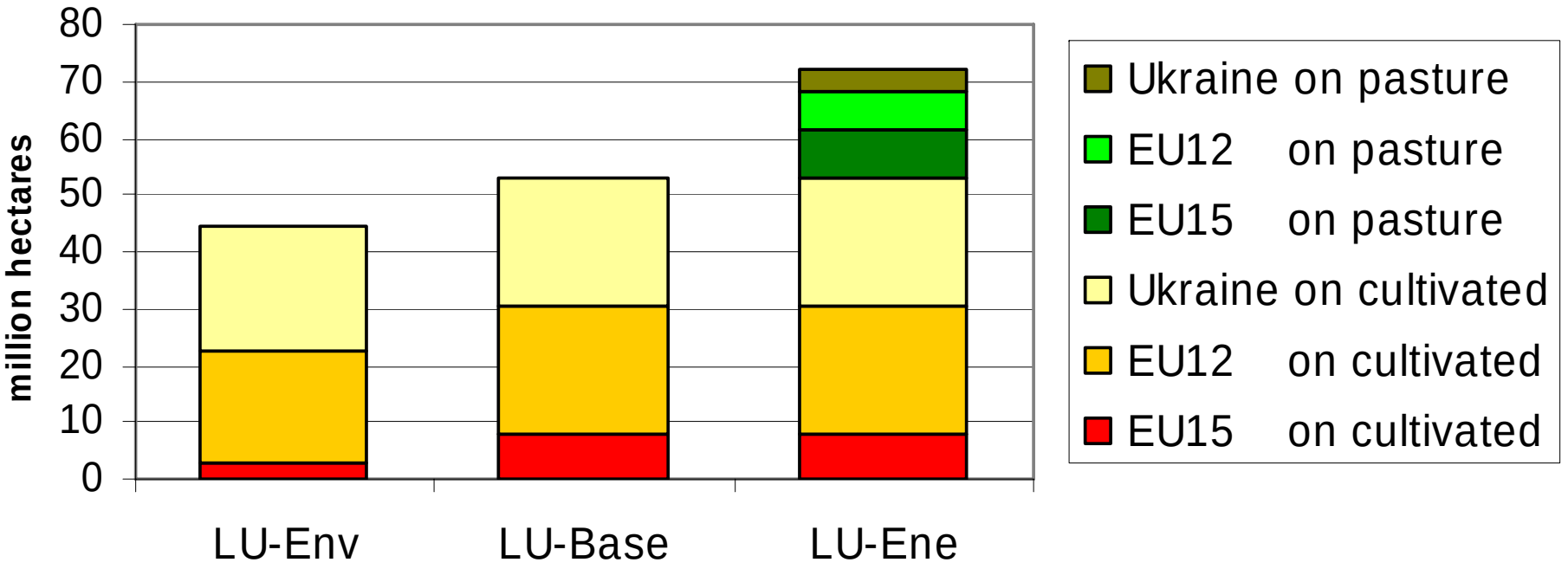
Aggregate crop yields observed in 2000-02 and assumptions for 2030



Land use scenarios - Results

Available LAND

Results 2030 – agricultural land for bio-energy crops

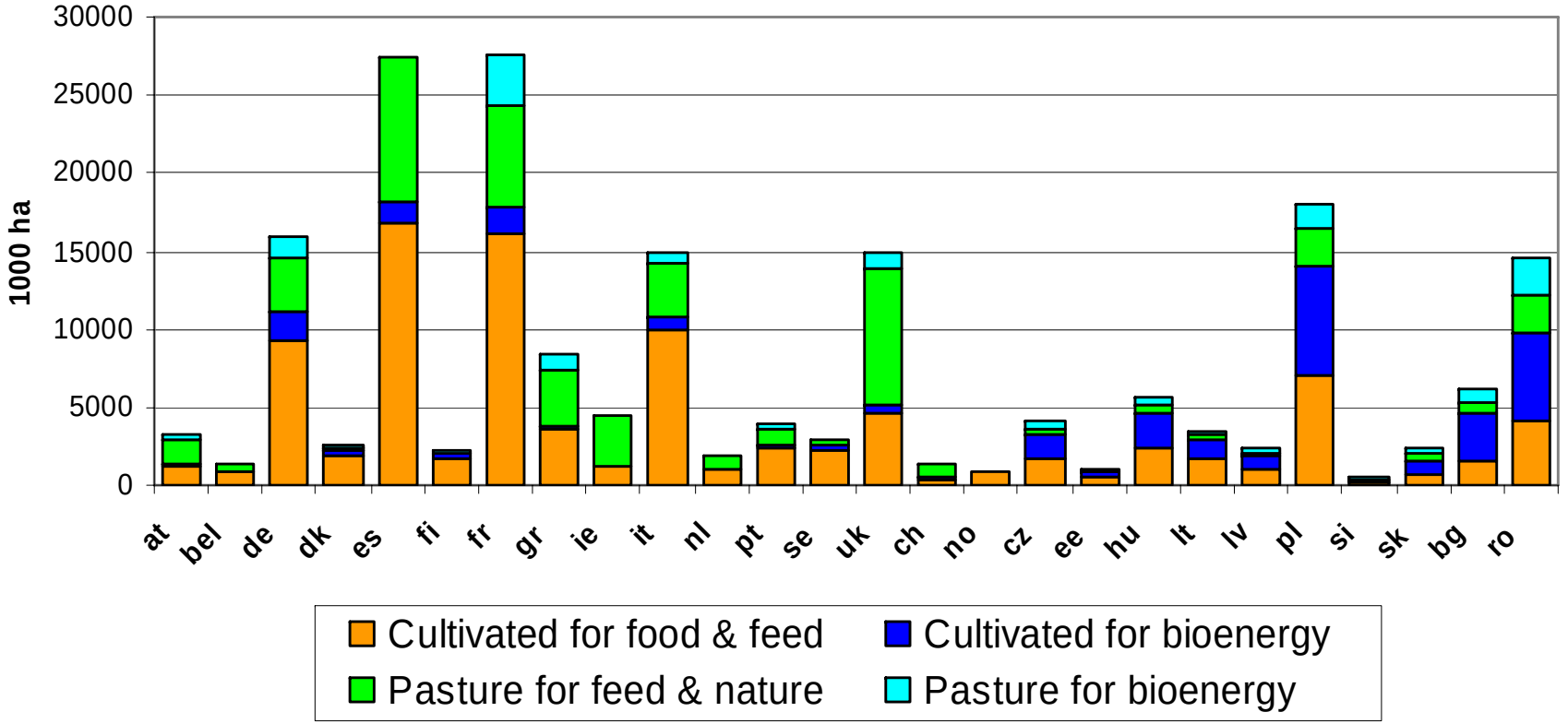


Source: Land Use Change & Agriculture Program, IIASA, 2007

Land use scenarios - Results

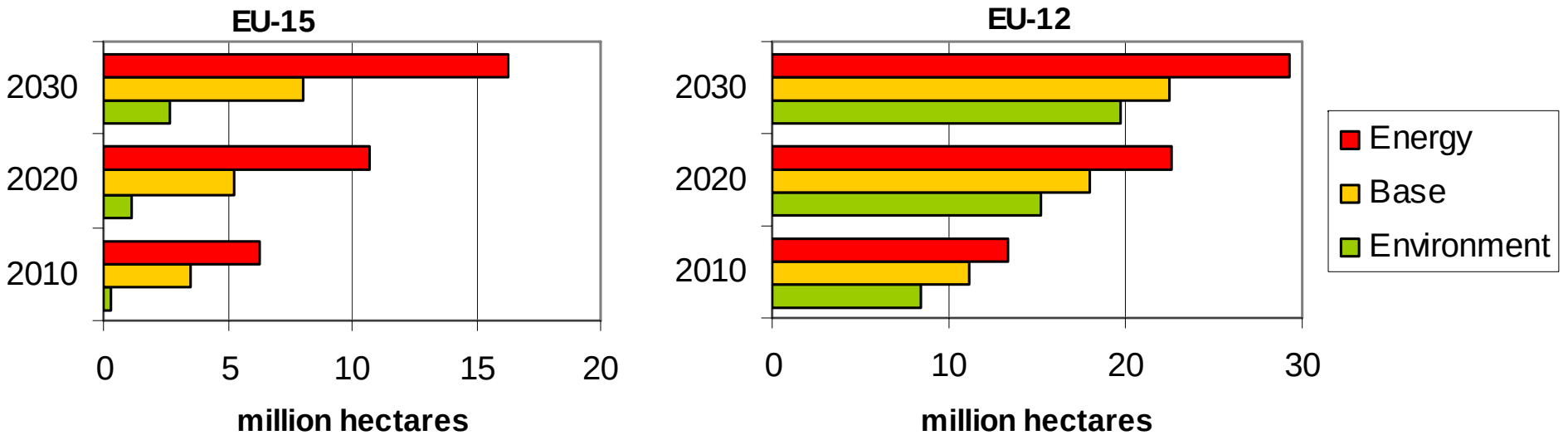
Available LAND

Possible agricultural land use in 2030 of European countries
(*'LU-Energy'* scenario)



Land use scenarios – Results for EU15 and EU12

Agricultural land potentially freed up for growing bio-energy feedstocks in EU15 and EU12 countries, for different scenarios



Source: Land Use Change & Agriculture Program, IIASA, 2007

Conclusions & Policy implications

- Large extents of agricultural land could become available for biomass production while satisfying food & feed demand.
- Regional differences – Importance of Eastern Europe
- By 2030, some 22 to 30 mio.ha cultivated land available in EU27 (+another 20 mio.ha in Ukraine). In addition some 15 mio. ha of pasture could be used for energy crops.
- With large areas to be used for bio-energy feedstock production, ***sustainability*** of production will be crucial for public acceptance (crop rotations, agricultural intensity, biodiversity impacts, nitrogen losses, net GHG savings, …).

DG-AGRI (Jan.2007)

The impact of a minimum 10% obligation for biofuel use in the EU-27 in 2020 on agricultural markets

- They conclude that the 10% scenario does not overly stretch the land availability nor does it lead to a significant increase of intensities of production because of the limited pressure on markets.
- Projections are based on the assumption that 30% of the biofuels would come from second-generation fuels, whereas 20% would be imported.
- Total arable area biofuels: **17.5 mio.ha** (15% of arable)
  7.1 mio.ha ethanol 1st; 5.2 mio.ha ethanol 2nd.; 0.6 mio.ha ethanol sugar beets; 2.9 mio.ha biodiesel 1st; 1.7 mio.ha BTL
- By 2020: 16 mtoe bioethanol + 4 mtoe biodiesel

However ...

- Only moderate answer to the biofuels drivers
  - GHG savings 40-60%
  - Limited land efficiency
  - Moderate options for innovation, competitiveness
  - What if 10% is not sufficient?

Second-generation biofuels score significantly better on all these criteria

Thank you!

Contact details:
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http://www.iiasa.ac.at/Research/LUC