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Indirect Land Use Change (iLUC) Modelling: Understanding Limitations and Alternatives

the Council of the European Union

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André Faaij

Scientific Director, Copernicus Institute – Utrecht University;

Head of Unit, Energy & Resources

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Why biobased economy?

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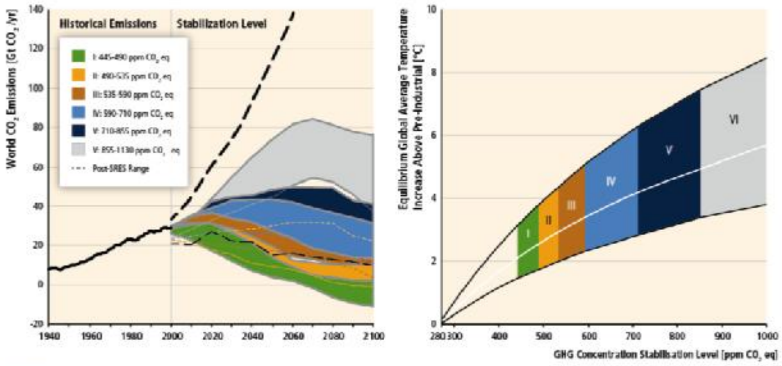
Energy demand, GHG emissions and climate change…



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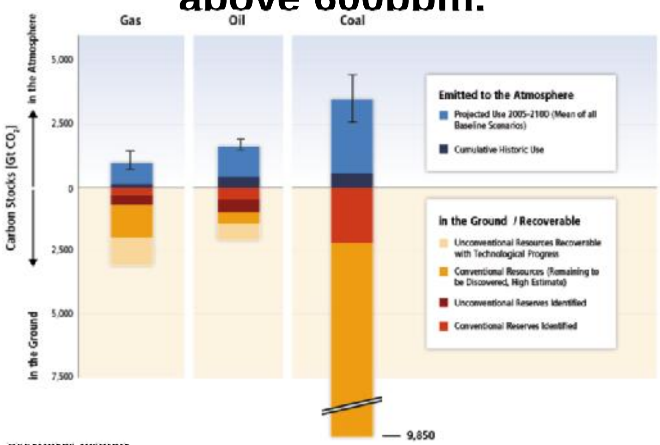
Potential emissions from remaining fossil resources could result in GHG concentration levels far above 600ppm.



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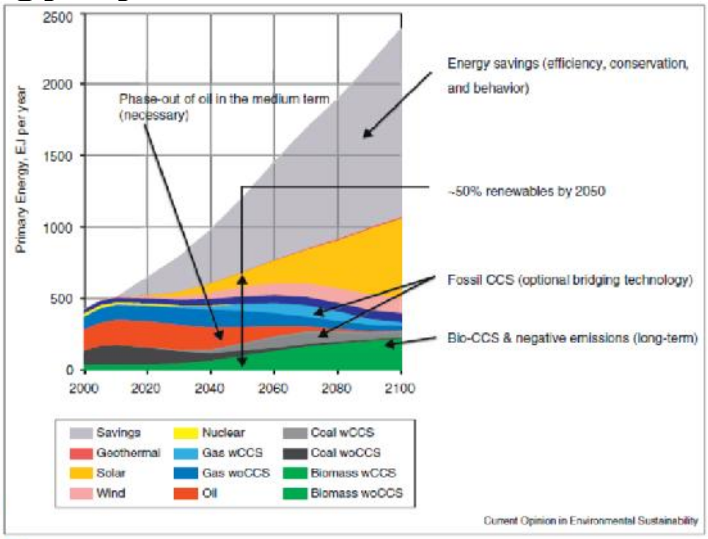
Energy system transformation…



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[GEA/van Vuuren et al CoSust, 2012]

Advancing markets…pushed by technological progress and pulled by high oil prices

- Advanced biofuels…(strong economic perspective)
- Biorefining, biochemicals, biomaterials…
- Aviation and shipping…

- Likely to compete for the same resources…
- Should meet the same sustainability criteria…(but that is not the case today!)
- Competition or synergy?

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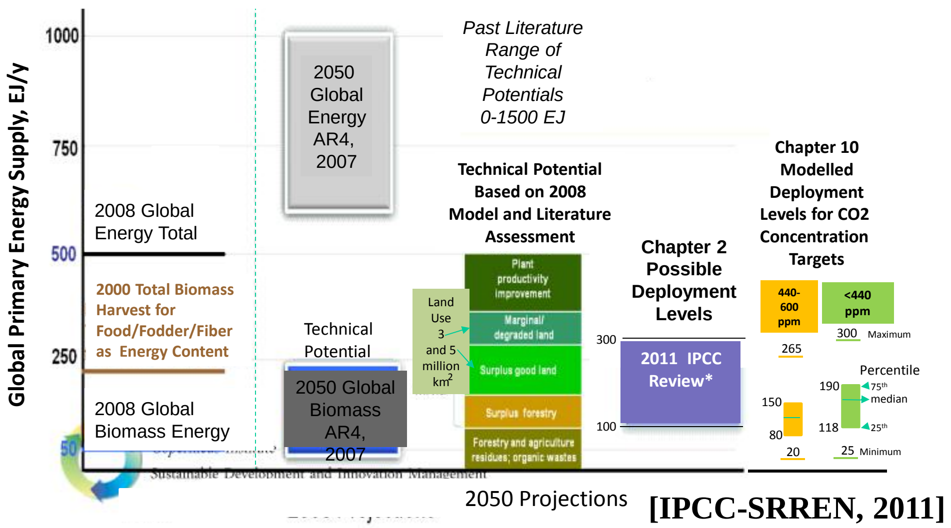
Biomass resources; potentials <-> preconditions

2050 Bioenergy Potentials & Deployment Levels



[IPCC-SRREN, 2011]

Driving forces, dimensions, scales…

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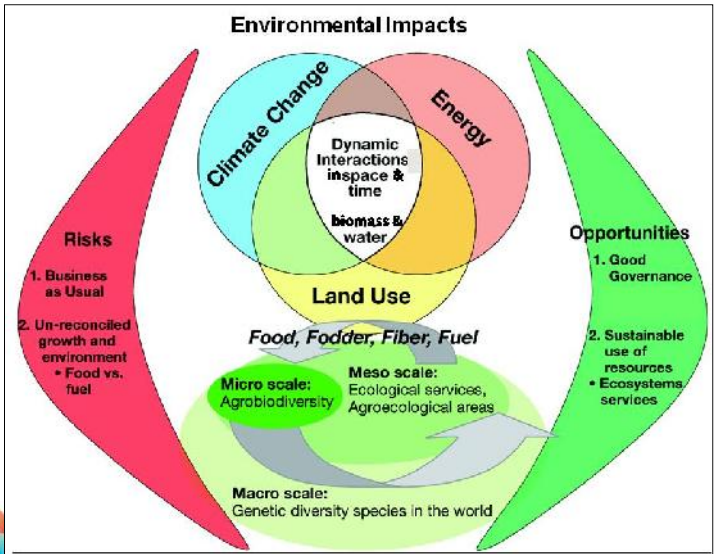

[IPCC-SRREN, 2011]

Key factors biomass potentials

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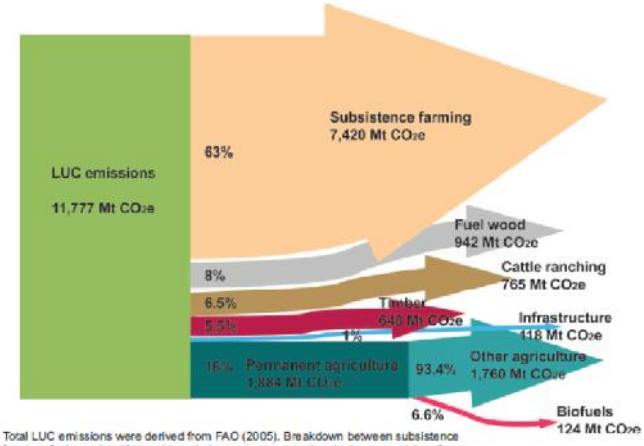
Issue/effect	Importance
Supply potential of biomass	
Improvement agricultural management	***
Choice of crops	***
Food demands and human diet	***
Use of degraded land	***
Competition for water	***
Use of agricultural/forestry by-products	**
Protected area expansion	**
Water use efficiency	**
Climate change	**
Alternative protein chains	**
Demand for biomaterials	*
Demand potential of biomass	
Bio-energy demand versus supply	**
Cost of biomass supply	**
Learning in energy conversion	**
Market mechanism food-feed-fuel	**

Dornburg et al., Energy & Environmental Science 2010

Contributors to land use change…



Total LUC emissions were derived from FAO (2005). Breakdown between subsistence farming, fuel wood, cattle ranching, timber and permanent agriculture were taken from FAO (1980). The contribution of biofuels was based on the proportion of commercial agricultural output allocated to biofuels over the period 2000 - 2005.

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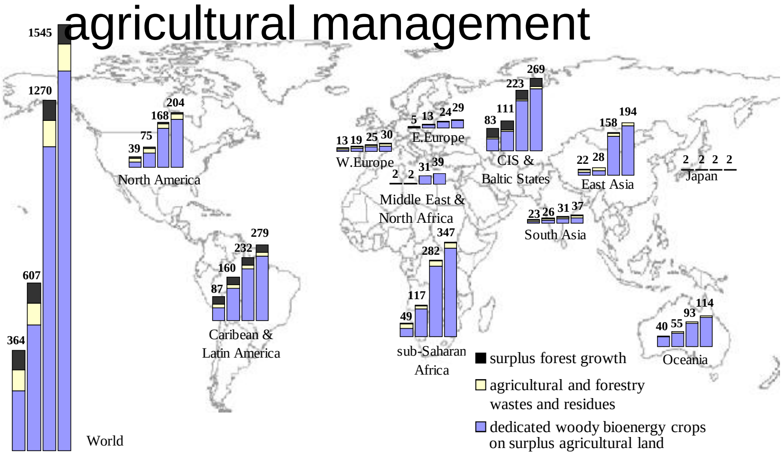
Bioenergy production potential in 2050 for different levels of change in agricultural management

Source: Smeets, Faaij 2007
Progress in Energy & Combustion Science



Total bioenergy production potential in 2050 based on system 1 to 4 (EJy^{-1}; the left bar is system 1, the right bar is system 4

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GHG mitigation peformance

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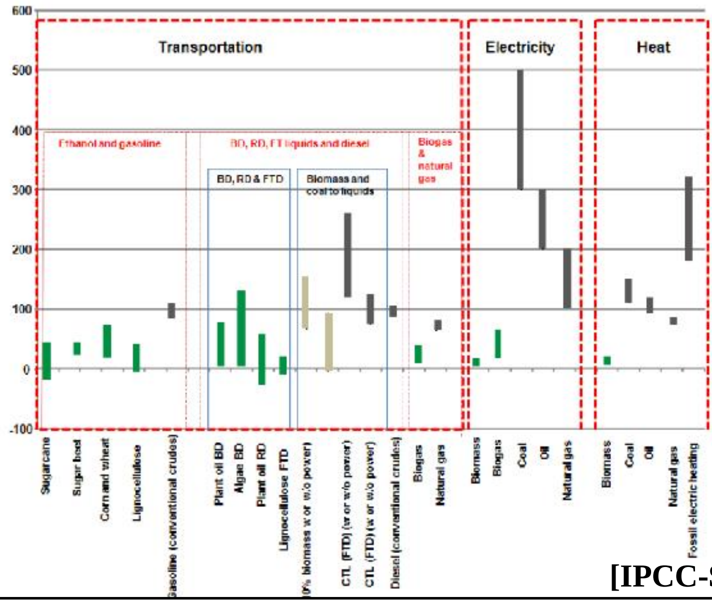
GHG/MJ of major modern bioenergy chains vs. conventional fossil fuel options



<u>Excluding</u> (i)LUC effects; these can have strong impacts

[IPCC-SRREN, 2011]

Direct land use change GHG emissions examples

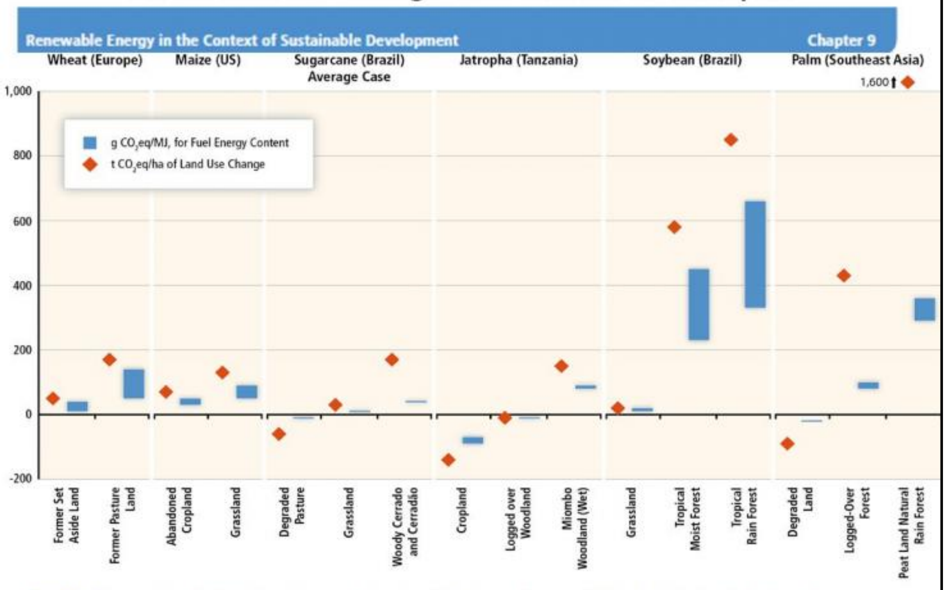


Figure 9.10 | Illustrative direct LUC-related GHG emission estimates from selected land use types and first-generation biofuel (ethanol and biodiesel) feedstocks. Results are taken from Hoefnagels et al. (2010) and Fargione et al. (2008) and, where necessary, converted (assuming a 30-year timeframe) to the functional units displayed using data from Hoefnagels et al. (2010) and EPA (2010b). Ranges are based on different co-product allocation methods (i.e., allocation by mass, energy and market value).

Site and prior use specific ....

Direct and indirect land use GHG emissions – Take II (Chapter 9)

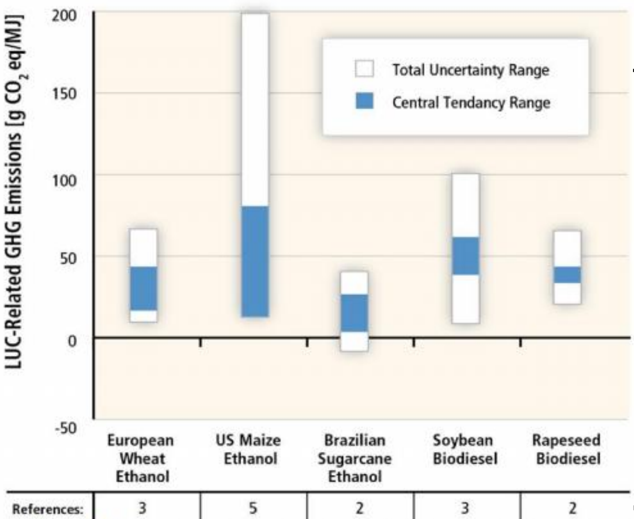


Figure 9.11 | Illustrative estimates of direct and indirect LUC-related GHG emissions induced by several first-generation biofuel pathways, reported here as ranges in central tendency and total reported uncertainty. Estimates reported here combine several different uncertainty calculation methods and central tendency measures and assume a 30-year time frame. Reported under the x-axis is the number of references with results falling within these ranges (Sources: Searchinger et al., 2008; Al-Riffai et al., 2010; EPA, 2010b; Fritsche et al., 2010; Hertel et al., 2010; Tyner et al., 2010).

Uncertain!!!

'depreciation Carbon losses over 20 years; after that iLUC = zero.

Carbon intensity fossil ref excludes upstream Emissions. These will increase (>200 g/MJ possible)

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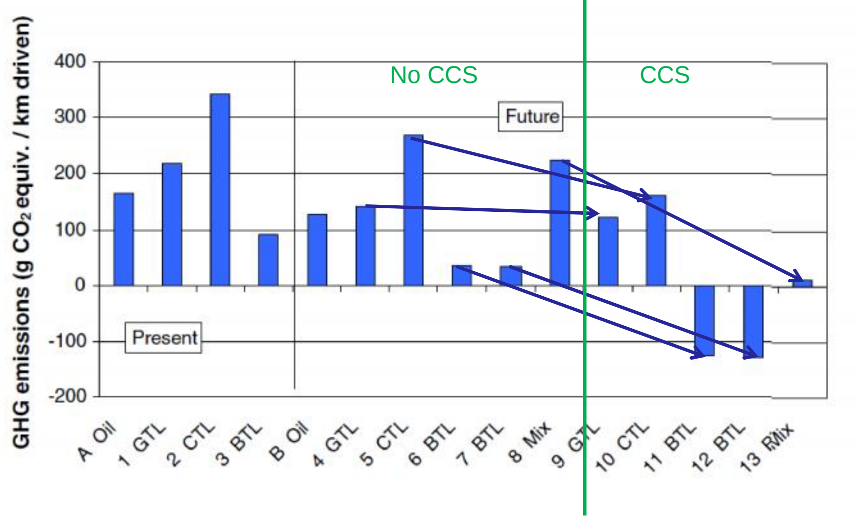
GHG emissions per km driven



[Van Vliet et al., 2009]

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iLUC; scientific status, gaps next steps…

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Confrontation bottom-up vs. top down iLUC modelling

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Key steps iLUC modelling efforts:

- CGE; historic data basis
- Model shock, short term, BAU, current technology.
- Quantify LUC
- Quantify GHG implications (carbon stocks)

Bottom-up insights:

- Coverage of BBE options, advancements in agriculture, verification of changes (land, production)
- Gradual, sustainability driven, longer term, technological change (BBE, Agriculture
- LUC depends on zoning, productivity, socio-economic drivers
- Governing of forest, agriculture, identification of ''best'' lands.

[IEA & other workshops, 2011-2013; pubs under preparation]

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Example: Corn ethanol Results from PE & CGE models

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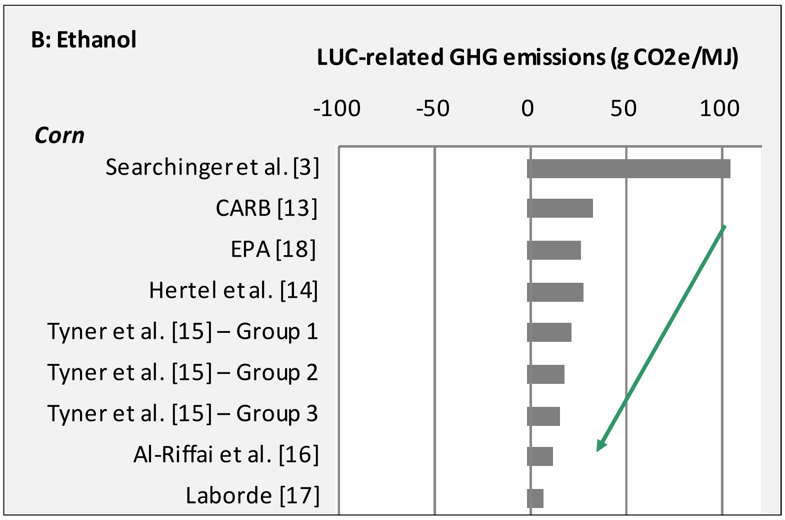

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[Wicke et al., Biofuels, 2012]

iLUC mitigation options…

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- Controlling (i)LUC
  - Increasing efficiency in agriculture, livestock and bioenergy production
  - Integrating food, feed and fuel production
  - Increasing chain efficiencies
  - Minimizing degradation and abandonment of agricultural land
- Controlling type of LUC
  - Sustainable land use planning (incl. monitoring)
  - Excluding high carbon stock and biodiversity areas
  - Using set-aside, idle or abandoned agricultural land
  - Using degraded and marginal land

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Redesigning modelling frameworks & scenario's

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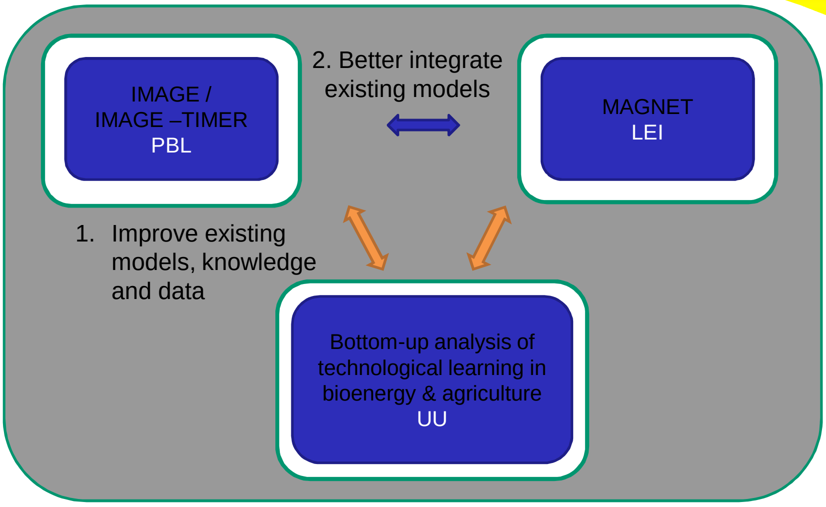

Coordinated 4 year program by Utrecht University
Supported by iLUC mitigation research in many countries.

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Question form:

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- Do we have enough modeling capabilities, methods, data and tools to provide *sufficient* answers to policy and the market (on iLUC)?
- Are the right questions being asked to science? (quantify iLUC vs. mitigation of iLUC)
- Honesty, limitations, uncertainties and the science – policy interface…
- What are we trying to govern?; how to prioritize GHG, energy, land-use, agriculture, forestry, rural development…

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Policy debate

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- Changing perspectives: from iLUC to mitigation.
- Broader support for the view that focus on biomass/biofuels alone is inconsistent.
- Modernization and efficiency of conventional agriculture (and livestock essential in itself (!)
- Leads to different perspective from avoiding problems to achieve synergies (governance land).
- Essential: **“**incentivise practices that prevent or mitigate ILUC”; only penalizing leads to stagnation
- Mitigation of iLUC can be translated into extended sustainability criteria!

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Contrast:

- Modeling for iLUC factors is only half the science we need; **reactive** instead of **pro-active** concept.
- Biofuel policies also half the policy we need; mandates without proper preconditions, resulting in **CONFLICTS**

Versus

- Interlinked agricultural& biobased economy policies (agri, clima, energy…).
- Investigate (and implement) Integral land use strategies (agriculture, BBE, nature, rural development) to achieve **SYNERGIES**

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Thanks for your attention

For more information, see:

- **Sciencedirect/Scopus (scientific)**
- **Google scholar citations (personal)**
- **http://srren.ipcc-wg3.de/report (IPCC)**
- **www.bioenergytrade.org (IEA)**

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Challenges for science, business and policy

- ***Land & natural resources (local – global)***
  - Integral land use strategies (agriculture, BBE, nature, rural development)
  - Full impact analyses and optimization;
  - Include 'macro''-themes; iLUC, food security, rural development, water/biodiversity.
  - Governance…
- ***Drive down the learning curves***
  - Technologies (fuels, biomaterials, power, carbon management (CCS)
  - Cropping systems
  - Logistics, markets, CoC
  - Business models & investment.

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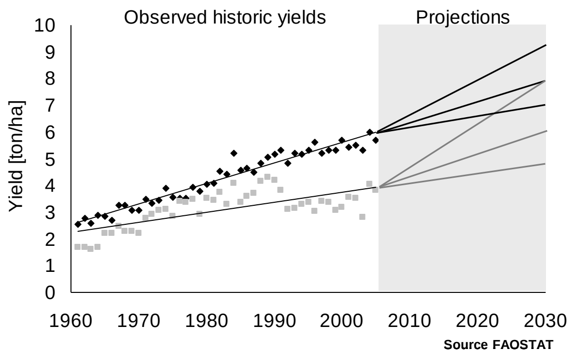
Yield projections Europe

Observed yield
- CEEC and WEC

Linear extrapolation of historic trends
- Widening yield gap

Applied scenarios
- Low, baseline and high



[Wit & Faaij, Biomass & bioenergy, 2010]

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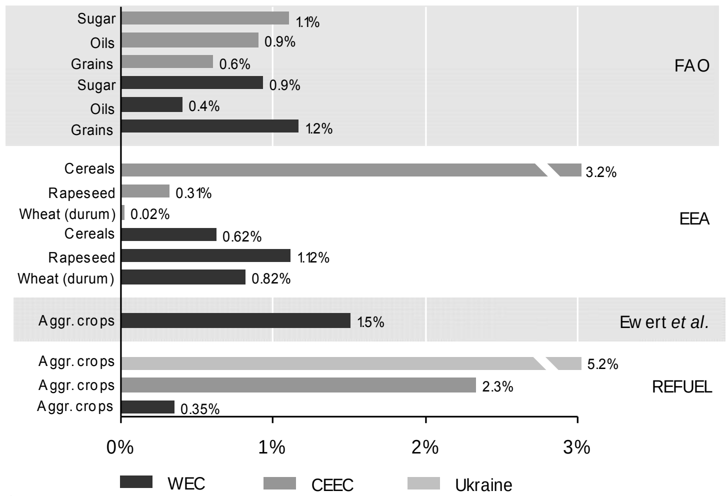
Average annual yield growth rate projections for Europe for the period 2000-30 for four studies



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De Wit, et al., RSER 2011

Absolute productivity increases and relative growth rates for the period 1961-2007 and per decade.

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		Absolute 1961-2007 kg $ha^{-1} y^{-2}$ kg $animal^{-1} y^{-1}$	Relative 1961-2007	'61-'69	'70-'79 % y^{-1}	'80-'89	'90-'99	'00-'07
France	Wheat	104	**3.6**	5.2	2.5	2.5	1.6	-0.9
	Rapeseed	40	**2.5**	1.4	0.3	-0.3	2.1	1.2
	Sugarbeet	1024	**3.1**	3.6	0.2	2.4	1.0	2.8
	Cattle	2.8	**1.6**	0.5	1.2	0.9	-0.1	0.9
Netherlands	Wheat	110	**2.7**	0.7	3.8	1.4	0.5	-0.6
	Rapeseed	25	**1.0**	-0.6	-1.8	-0.1	0.6	0.2
	Sugarbeet	489	**1.2**	2.6	0.1	1.4	-1.9	2.5
	Cattle	1.1	**0.6**	0.7	0.9	2.1	-0.9	-1.0
Poland	Wheat	39	**1.8**	3.6	2.3	4.1	-0.6	1.6
	Rapeseed	21	**1.4**	1.7	0.4	-0.4	-0.6	4.0
	Sugarbeet	319	**1.2**	3.5	-0.5	2.6	1.0	3.7
	Cattle	2.5	**2.7**	3.6	6.1	4.9	0.6	10.1
Ukraine *(USSR)* [a]	Wheat	*n.a.*	*n.a.*	5.1	1.0	3.6	-4.5	-0.2
	Rapeseed	*n.a.*	*n.a.*	3.5	-2.7	-0.4	-7.4	9.4
	Sugarbeet	*n.a.*	*n.a.*	9.0	0.3	5.0	-3.2	11.3
	Cattle	*n.a.*	*n.a.*	6.3	2.1	2.1	-4.9	1.2

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De Wit, et al., RSER, 2012

Source: FAOSTAT and own calculations

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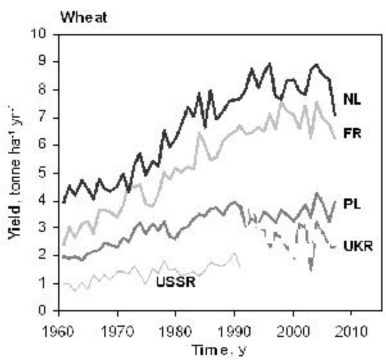
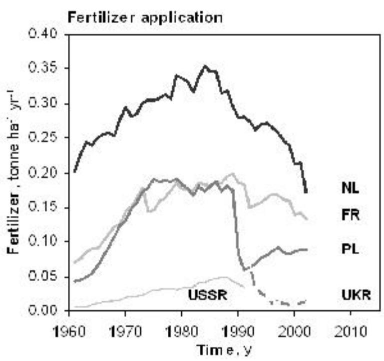
Developments in yields and inputs





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[De Wit et al, RSER 2011]

Selected remarks on yields

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- Yield growth projections in WEC at 0.5-1.5% y-1, are modest when compared to historic developments between 1961-2007, but seems high compared to developments in the last two decades. Declining growth rates in the latter period, explained by an expansion in organic farming, set-aside obligations and a decoupling of production support. REFUEL projections (0.4% y-1) for the WEC seem conservative in this respect.

- Projected growth rates for the CEEC around 1% y-1 – as projected by FAO (0.9% y-1) and EEA (1.2% y-1) – seem modest when compared to average growth figures between 1961 and 2007, even more so when compared to growth rates prior to 1990 and past 2000.

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De Wit, et al., RSER 2012

Results - spatial production potential

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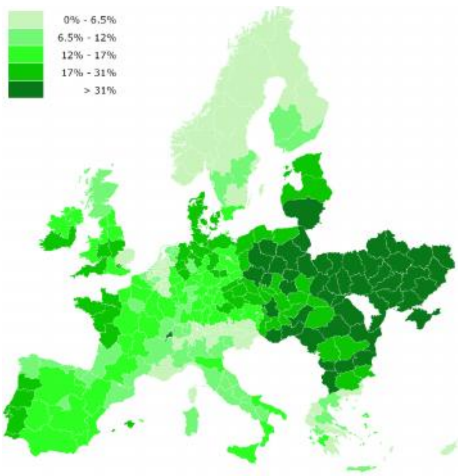
Arable land available for dedicated bio-energy crops divided by the total land

Potential		Countries
Low potential	< 6,5%	NL, BE, LU, AT, CH, NO, SE and FI
Moderate potential	6,5% - 17%	FR, ES, PT, GE, UK, DK, IE, IT and GR
High potential	> 17%	PL, LT, LV, HU, SL, SK, CZ, EST, RO, BU and UKR



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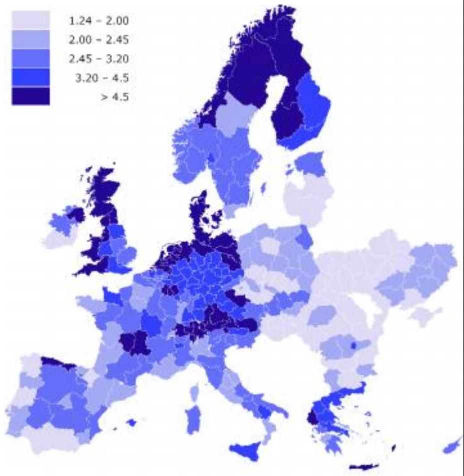
[Wit & Faaij, Biomass & Bioenergy, 2010]

Results - spatial cost distribution

Production cost (€ GJ^{-1}) for Grassy crops

Potential		Countries
Low Cost	< 2,00	PL, PT, CZ, LT, LV, UK, RO, BU, HU, SL, SK, EST, UKR
Moderate Cost	2,00 – 3,20	FR, ES, GE, IT, SE, FI, NO, IE
High Cost	> 3,20	NL, BE, LU, UK, GR, DK, CH, AT



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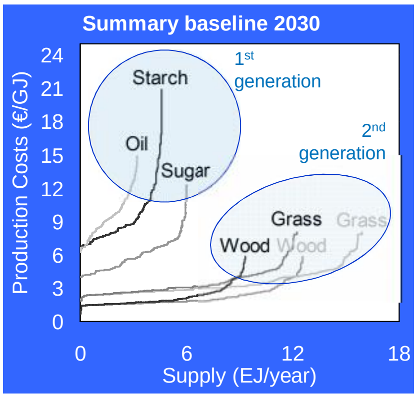
[Wit & Faaij, Biomass & Bioenergy, 2010]

Crop specific supply curves

- Feedstock potentials
  Produced on 65 Mha arable and 24 Mha on pastures (grass and wood)
- Significant difference between '1st and 2nd generation crops'
- Supply potentials high compared to demand
  2010 (0,78 EJ/yr) and 2020 (1,48 EJ/yr)



1 EJ (ExaJoule) = 24 Mtoe

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[Wit & Faaij, Biomass & Bioenergy, 2010]

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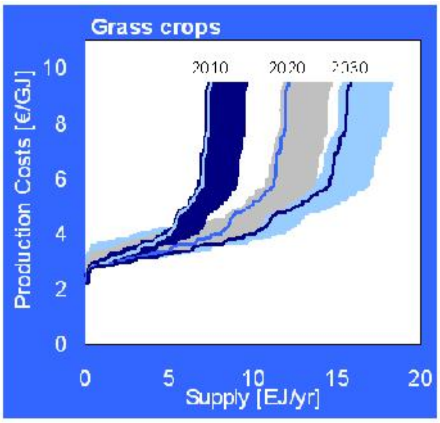
Results – cost-supply curves

Production costs vs. supply potential

for 2010, 2020 and 2030

Variation areas indicated around the curves represent uncertainties and scenario variables.

Only CEEC cost level increases



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[Wit & Faaij, Biomass & Bioenergy, 2010]

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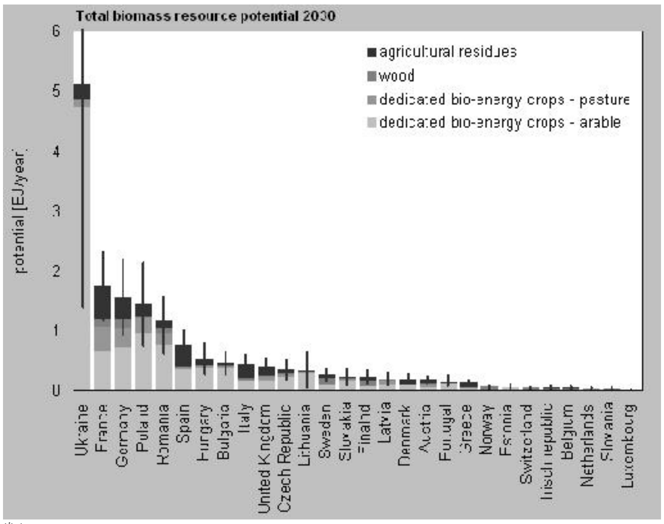
Total annual biomass supply potential, per European country.



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[Wit & Faaij, Biomass & Bioenergy, 2010]

Total energy potential under three different crop schemes.

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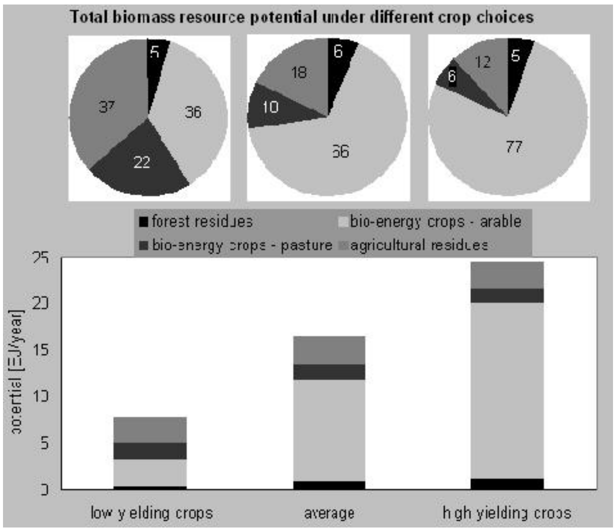
Low yielding crops': all arable land available planted with oil crops. 'High yielding crops': all available land planted with grass crops.



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[Wit & Faaij, Biomass & Bioenergy, 2010]

Developments coupled to drivers

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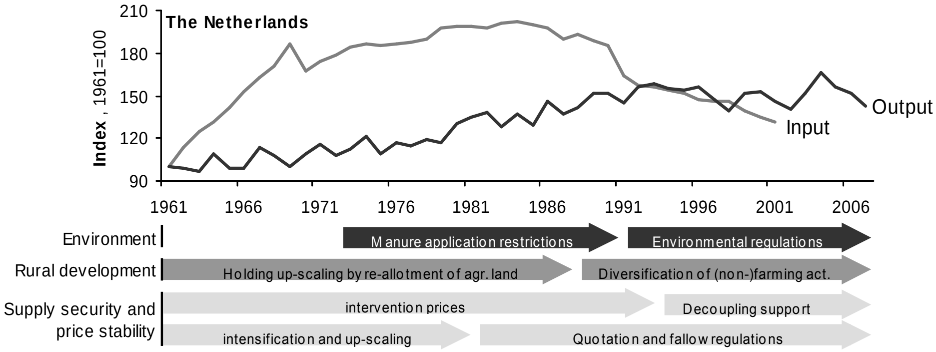
Example: the Netherlands

Inputs (fertilizer, machinery, labour and pesticides)

Outputs (wheat, sugarbeet, rapeseed and cattle)



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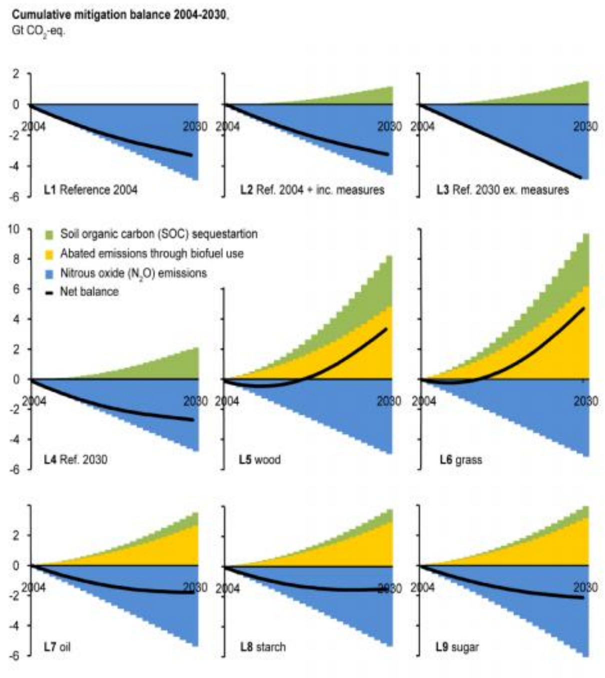
[De Wit et al, RSER 2011]



Example:
GHG balance of combined agricultural intensification + bioenergy production in Europe + Ukraine

[Wit et al., GCB-B Under review]

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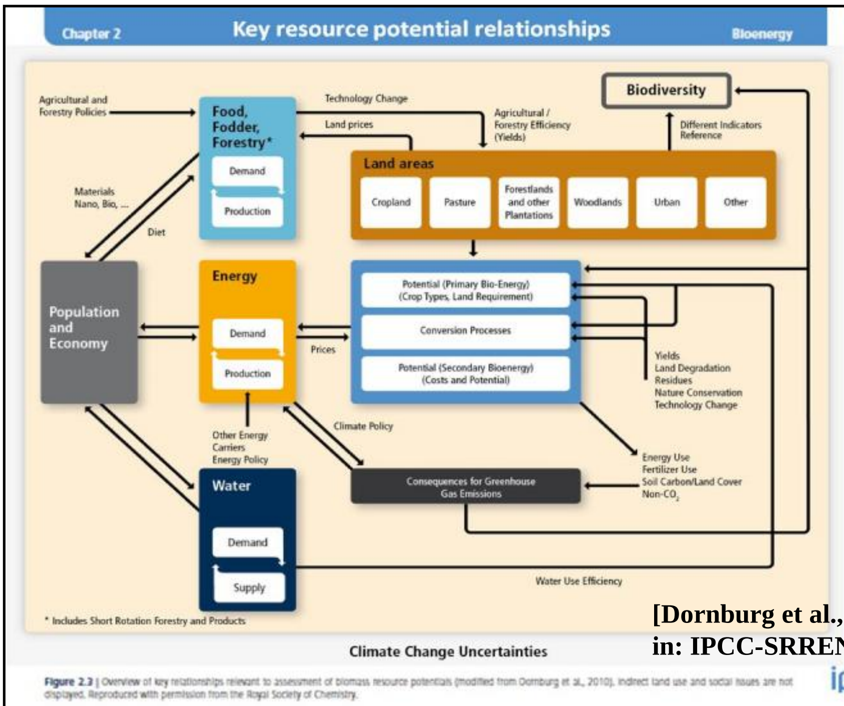
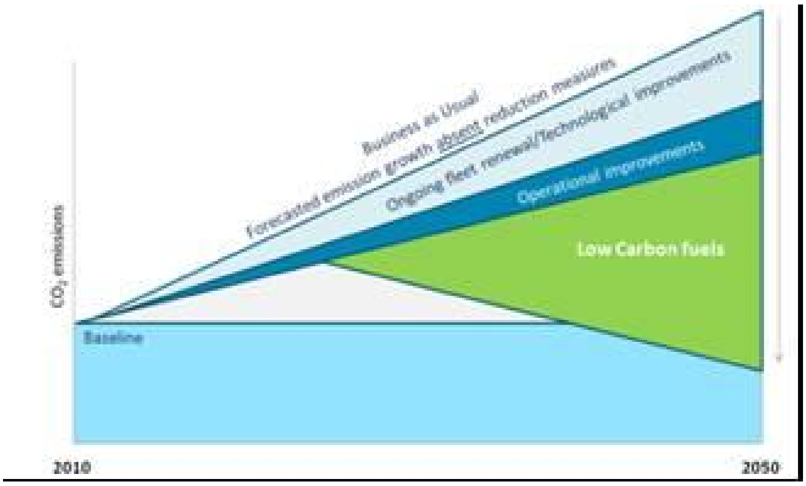


[Dornburg et al., 2010 in: IPCC-SRREN, 2011]

Breakdown of CO2 reduction options for aviation till 2050



[IIATA, 2010]

Biobased chemicals; not covered in current global scenario's (to date…)!

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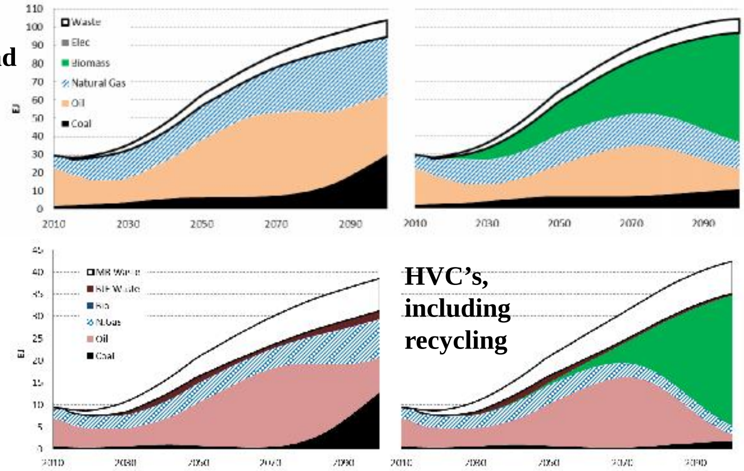
Energy demand for major Chemicals towards 2100 with and without Biomass deployment



HVC's, including recycling

[Daioglou et al., 2013 (forthcoming)]

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Biofuels; they are not going away.

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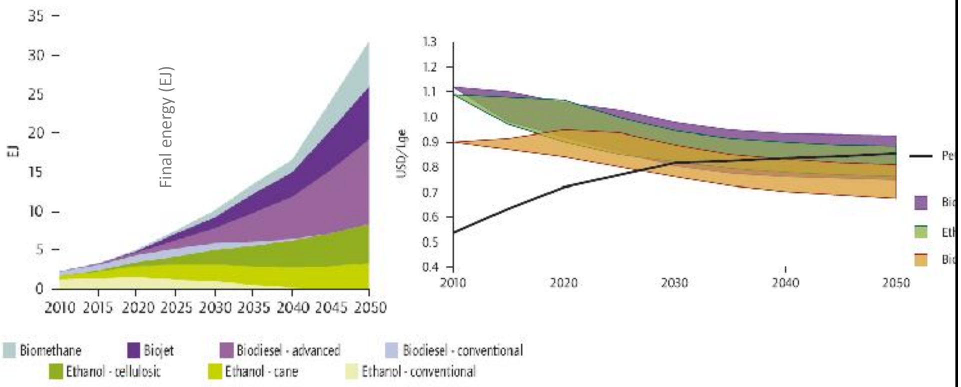

- Large-scale deployment of advanced biofuels vital to meet the roadmap targets
- **Advanced biofuels reach cost parity around 2030 in an optimistic case**

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[IEA Biofuels Roadmap]

A future vision on global bioenergy markets (2050…)

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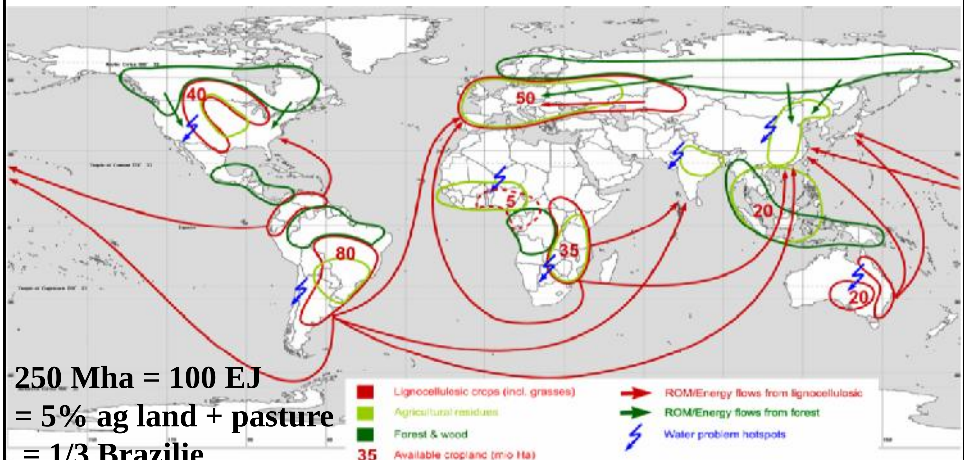

250 Mha = 100 EJ
= 5% ag land + pasture
= 1/3 Brazilie

[GIRACT FFF Scenario project; Faaij, 2008]

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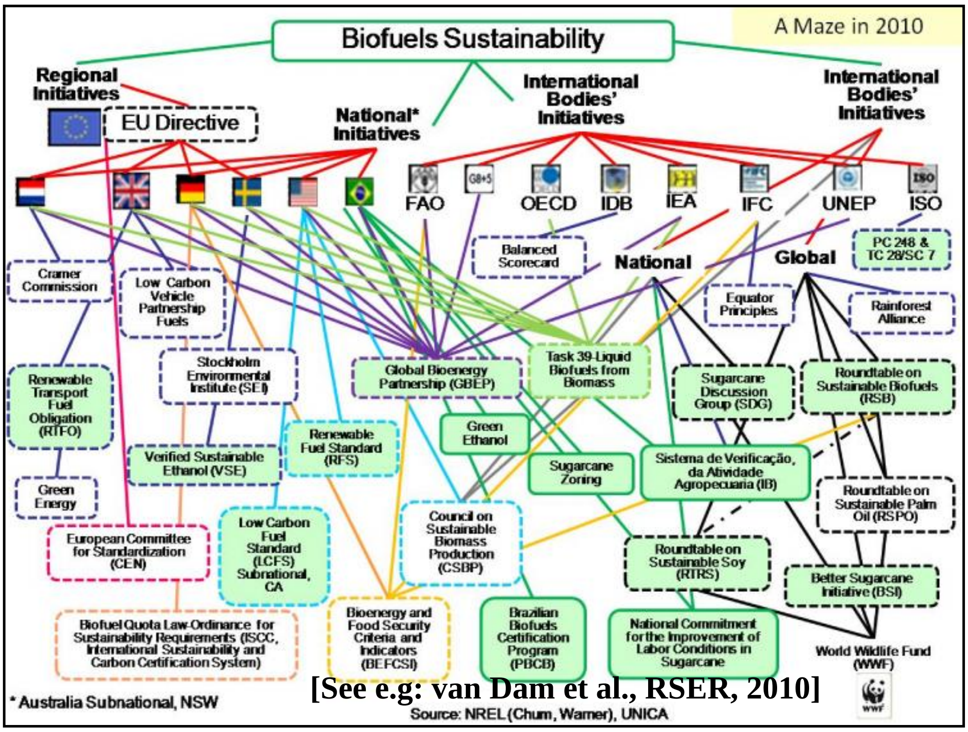

[See e.g.: van Dam et al., RSER, 2010]