

# SUSTAINABLE BIOENERGY SUPPLY STRATEGIES: UNCERTAINTIES, SYNERGIES AND TRADE-OFFS

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# Continued controversy about bioenergy...

- Strategies are needed to avoid undesirable land use change and food security effects of bioenergy (bioelectricity and 1<sup>st</sup> and 2<sup>nd</sup> generation biofuels) use.
- Potentially promising strategies are:
  - The use of 2<sup>nd</sup> generation biofuels instead of 1<sup>st</sup> generation biofuels
  - The use of residues from agriculture and forestry
  - The use of biomass from plantations

# Objectives

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- To investigate the land use change and food security effects of large scale use of bioenergy (bioelectricity and biofuels) from residues and plantations
- To investigate synergy and trade-off effects of strategies to avoid undesirable effects on land use and food security

# Approach

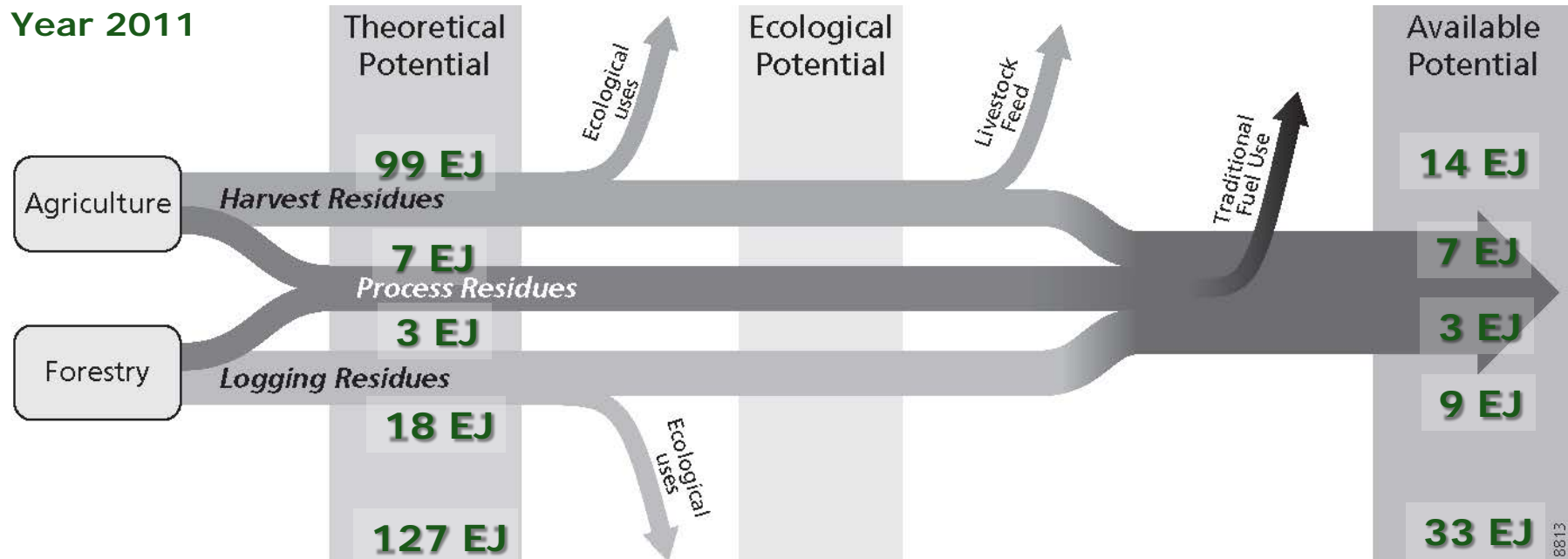
- Extended version of CGE model MAGNET (Modular Applied GeNeral Equilibrium Tool); new sectors:

Biomass demand	Biomass supply
Bioelectricity	Residues (agriculture, forestry)
2 <sup>nd</sup> generation biofuels	Plantations
(1 <sup>st</sup> generation biofuels)	Pellets

- Two extreme options of biomass plantations are considered:
  - ✓ plantations on land that competes with agricultural land
  - ✓ plantations on areas that are not suitable/interesting for conventional agriculture

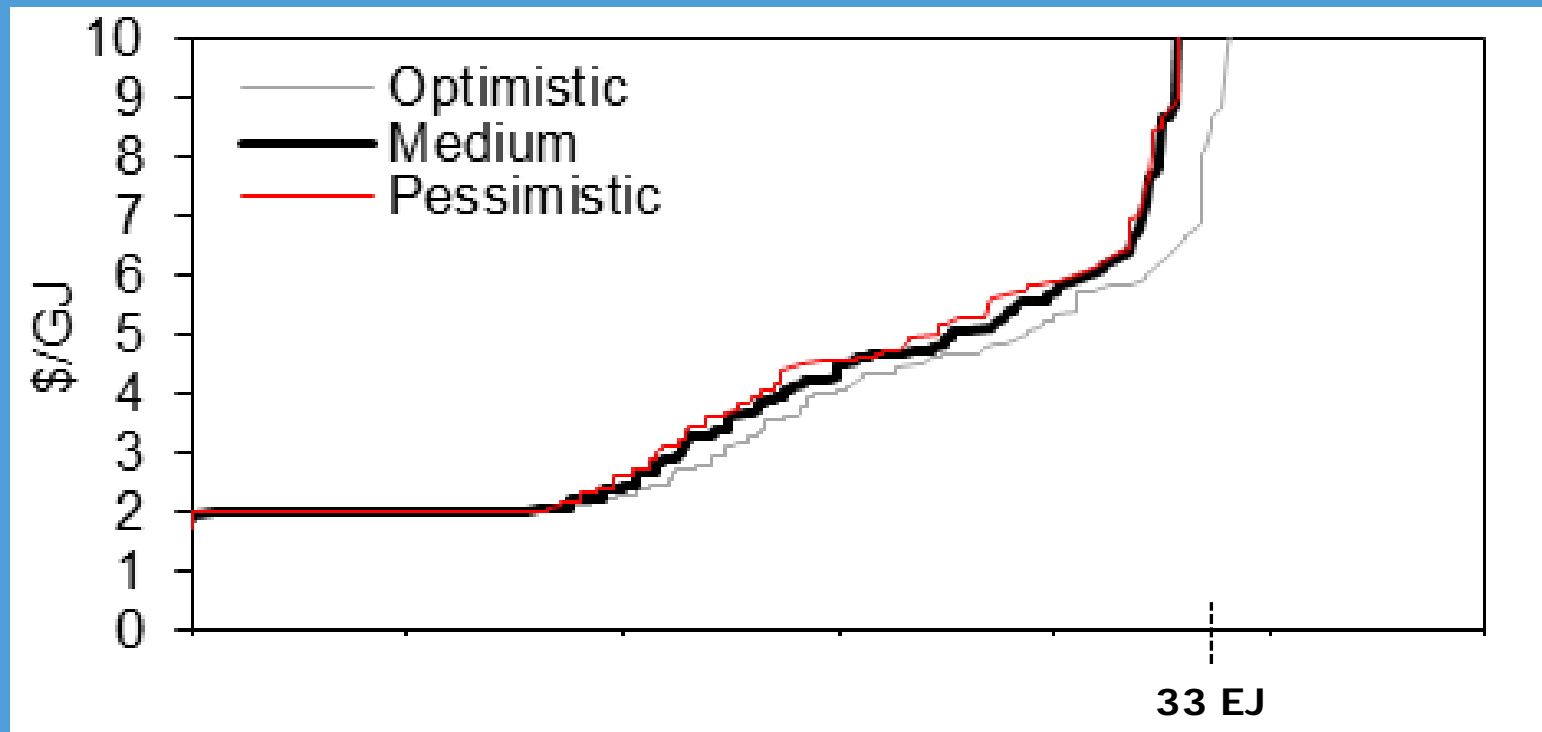
# Approach: residues

- Data from a detailed assessment of *sustainable* potential of residues from agriculture and forestry with IMAGE model



# Approach: residues

- Cost supply curve of *sustainable potential* of residues from agriculture and forestry implemented in MAGNET



# Scenarios

- Baseline scenario: GDP and population growth from SSP 2 scenario; bioenergy demand (TIMER)
  - Technological progress makes 2<sup>nd</sup> generation biofuels production competitive with 1<sup>st</sup> generation biofuels and fossil fuel in 2030 (oil @ 123 US\$/bbl in 2030)

<b>Difference in biomass demand in 2030 compared to baseline</b>	<b>EJ</b>
Bioelectricity	<b>7</b>
2nd generation biofuels	<b>28</b>

- High bioenergy use scenario: same as baseline, but with higher bioenergy use to avoid climate change (TIMER)

# Impact of large scale use of bioenergy

	<b>Plantations do not compete with agri land</b>	<b>Plantations compete with agri land</b>	
Biomass supply	60% residues 40% plantations	98% residues 2% plantations	
Biomass price	7	100	%
Plantation area	73	1	Mha
	1.4	0.02	% compared to agricultural area
Agricultural land use (exc. plantations)	8	25	Mha
	0.1	0.5	%
Agricultural land price	2	7	%
Production of agri products	0.2	0.6	%
Price of agri products	0.3	-1.0	%



# Impacts of residues

- Use of agricultural residues increases profitability of crop production, especially in North America, South East Asia, Indonesia and Russia/Ukraine/Asia Stan region
- Production increases and the price of agricultural commodities decreases, especially in regions with high potential of residues. And also food consumption increases!

Results for scenario plantations compete with agri land = <b>high</b> biomass price	<b>Production agri products</b>	<b>Consumption agri products</b>	<b>Price of agri products</b>
Regions with high pot. residues	1.4	1.6	-2.4
Regions with no/low pot. residues	0.4	0.5	-0.7
World	0.6	0.6	-1.0

# LUC and iLUC impacts of residues

- Impact of residues on agricultural land use depends on the price of residues and thereby on the supply of biomass from plantations:

	<b>Plantations do not compete with agri land</b>	<b>Plantations compete with agri land</b>	
	<b>= Low residue price</b>	<b>= High residue price</b>	
Crops	17	60	Mha
Livestock	-9	-35	Mha
Agri total	8	25	Mha

- Global NET land use change effects are very limited
- LUC effect of 2<sup>nd</sup> generation biofuels are much lower compared to 1<sup>st</sup> generation biofuels EU
- GHG effects are however not (yet) calculated

# Discussion and conclusions

- The sustainable potential of residues from agriculture and forestry is substantial (33 EJ in 2011) compared to the demand for biomass for energy
- Plantations on agricultural land are potentially unattractive due to higher prices of agricultural land (+200%; 2007-2030)
- Using harvest residues from agriculture is an incentive to expand agricultural production and increase food consumption
- The price of residues and thus the price of biomass from plantation determines production expansion effect of residues:  
constant biomass price: production agri products +0.2%;  
doubling of biomass prices: production +0.6%



# Discussion and conclusions

- The use of residues increases production and consumption in regions with large sustainable potentials; probably favourable for food security, not necessarily for all regions (e.g. India)
- The global net land use change effects of agricultural residues are limited, but involve conversion of pastures to cropland
- Future research topics:
  - Ecological impacts and constraints of using residue (soil organic matter; no-till management)
  - Market interactions with use of residues for other applications
  - Barriers for using residues for modern bioenergy production
  - Feasibility of plantations on marginal land, abandoned cropland, etc.
  - Impact on crop production technology
  - Food security effects; difference between consumers and producers

# Thank you for your attention

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