

# *MODELLING LAND-USE CHANGE IN BIOFUELS PRODUCTION: STATE OF THE ART*

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*Workshop on Land-Use Change and Bioenergy  
Oak Ridge National Laboratory-US Department of Energy*

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Vonore, TN, United States*

**Bioenergy and Energy Planning Research Group**

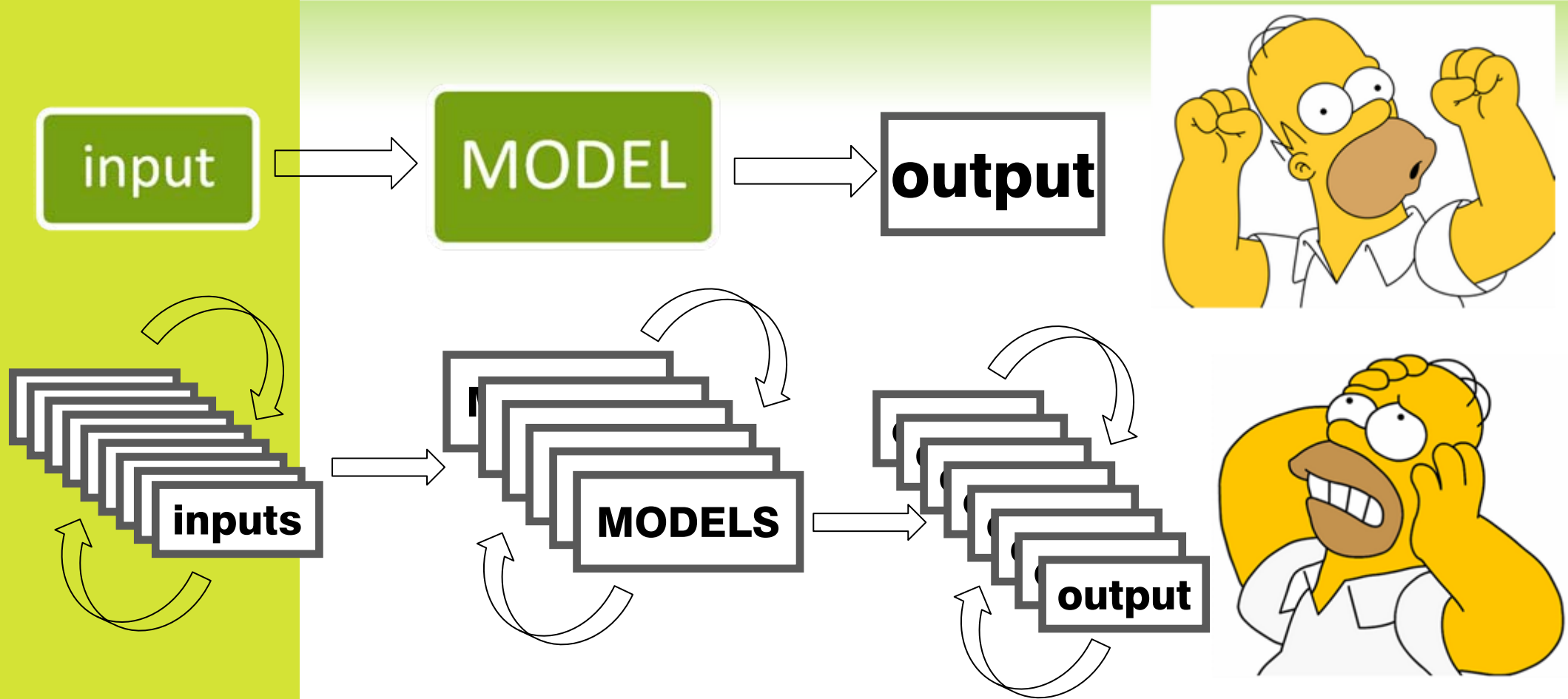
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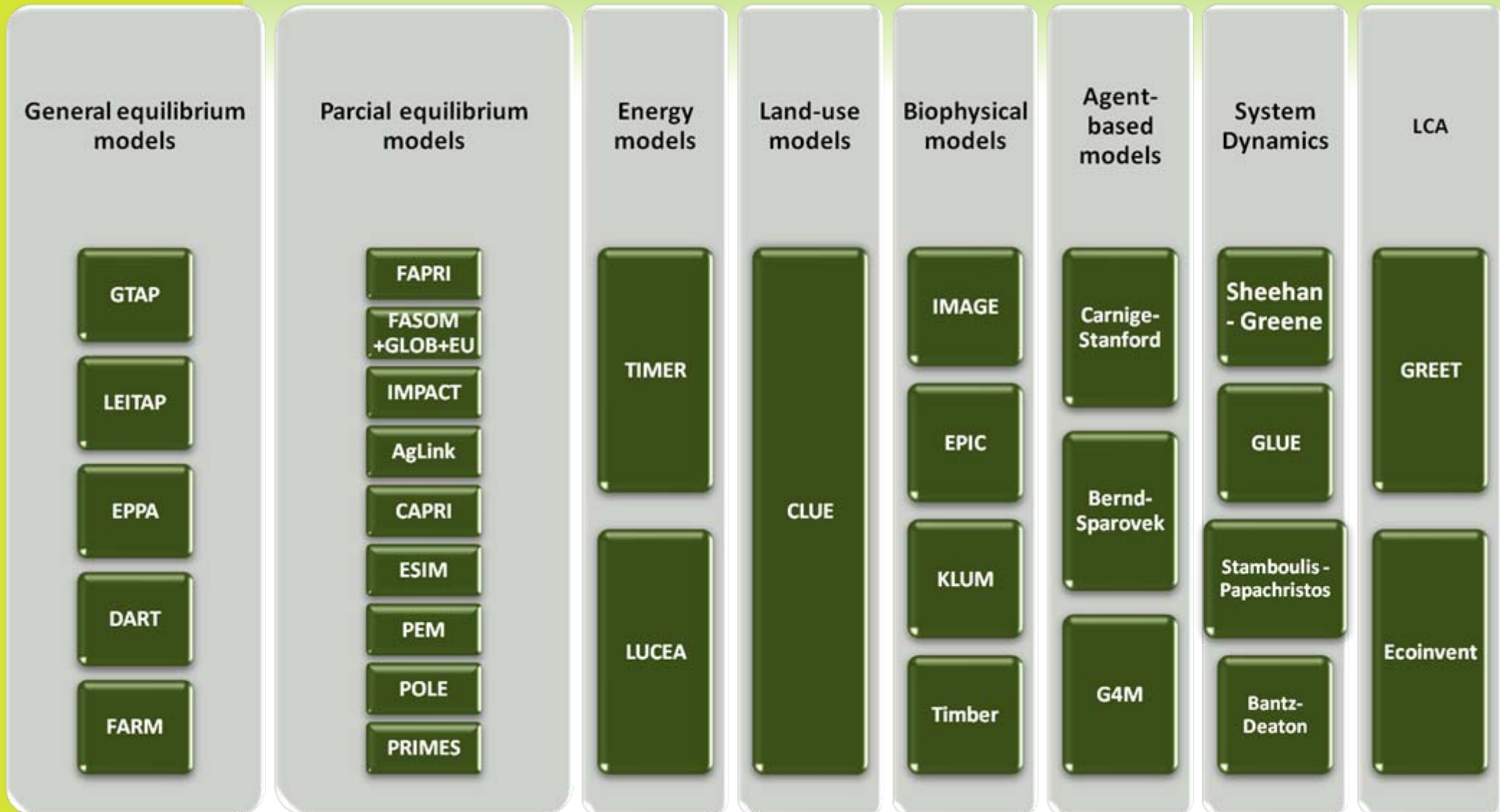


# THE PERFECT MODEL



- ⊙ One model can not tackle all issues
- ⊙ Uncertain inputs + uncertain parameters + uncertain models=uncertain results

# AVAILABLE MODELS DEALING WITH LUC IN BIOFUELS PRODUCTION



# MODELS INTEGRATION

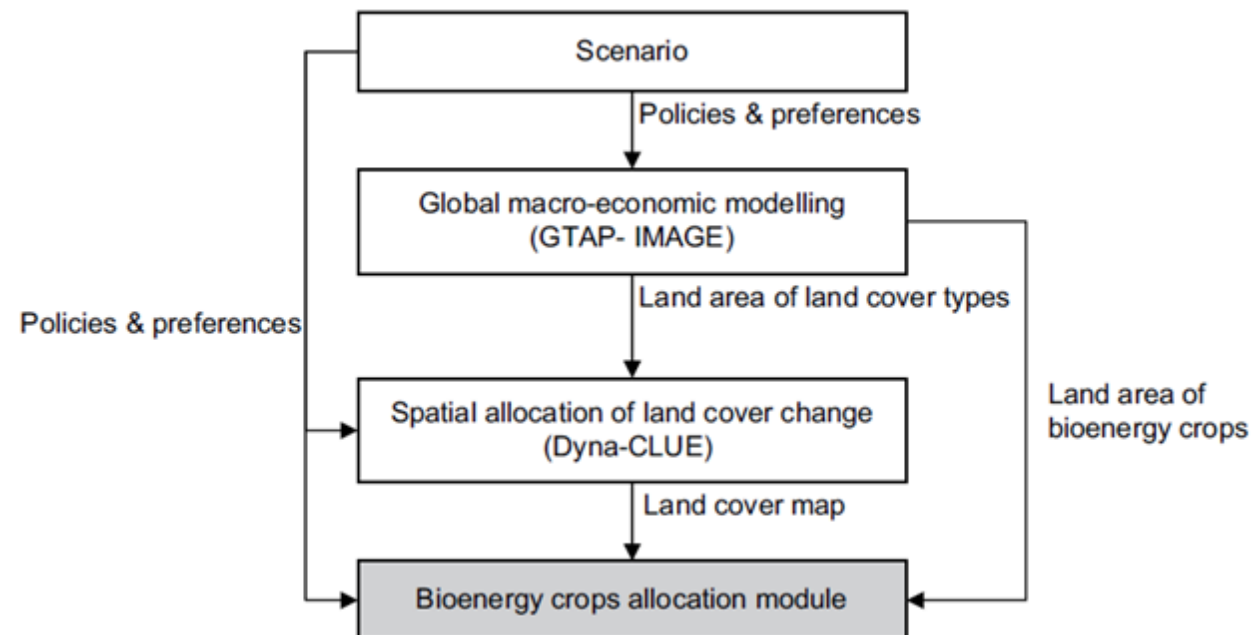
## Some examples

### Biophysical-economic models

- LEITAP-IMAGE (Banse et al.)
- GTAP-KLUM (Ronneberger et al.)

### Spatial – economic model

- LEITAP-IMAGE-DynaCLUE (Hellmann and Verburg)
- GIS-SD-ABM (Scheffran et al.)



Spatially explicit modelling of biofuel crops in Europe (Hellmann and Verburg, 2008)

# MODELS INTEGRATION

## ▪ Economic-environmental models

- GTAP- FAPRI -FASOM -GREET-Winrock- BESS-CENTURY- ASPEN-MOVES-NEMS (US-EPA)
- GTAP-CA-GREET (ARB-LCFS)
- GTAP-LCI (Kloverpris et al.)

## ▪ Economic-agricultural models

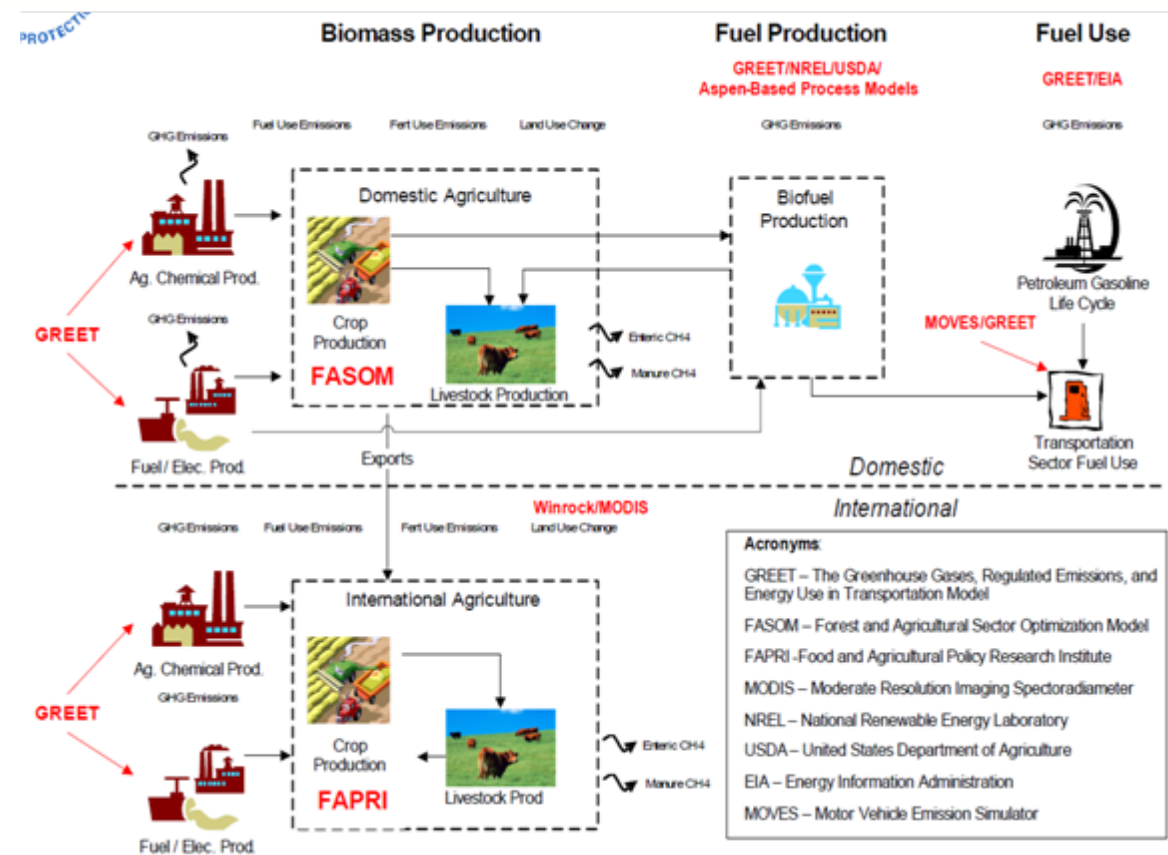
- AgLink-SAPIM (OECD)
- IFPSIM-EPIC (Banse et al.)
- GTAP-IMPACT-ABM (Fernandez et al.)
- GTAP-CAPRI-FSSIM (Van Ittersum et al.)

## ▪ Economic-forestry models

- GLOBIOM-G4M (Eururalis)

## ▪ Economic-energy models

- LEITAP-TIMER



US-EPA, 2009. GHG Lifecycle Modeling of Renewable Fuels

# DISCUSSIONS

## European Commission

Biofuels issues in the new legislation on the promotion of renewable energy. Public consultation exercise

- European Commission, April 2007

## Biofuel Assessment

Conference and Workshop on Modelling Global Land Use Implications in the Environmental Assessment of Biofuels

- Copenhagen, Denmark, 4–5 June 2007

## EEA/OECD

Linking economic and bio-physical modelling in relation to bio-energy

- Paris, France, 30 June 2008

## The Renewable Fuels Agency (RFA)

Practical solutions aimed at avoiding indirect land-use change resulting from biofuels production - Gallagher review

- London, United Kingdom, 21 October 2008

## Gleacher Center

Linking Biophysical and Economic Models of Biofuel Production and Environmental Impacts,

- Chicago, United States, 13-14 November 2008

## Roundtable on Sustainable Biofuels

Workshop on biofuels and Land Use Change

- São Paulo, Brazil, 20-21 November 2008

## JRC/EEA/OECD

Review and inter-comparison of modelling land use change effects of bioenergy

- Paris, France, 29-30 January 2009

## IEA Bioenergy-Task 38

Land Use Changes due to Bioenergy Quantifying and Managing Climate Change and Other Environmental Impacts

- Helsinki, Finland, March 30th – April 1st, 2009



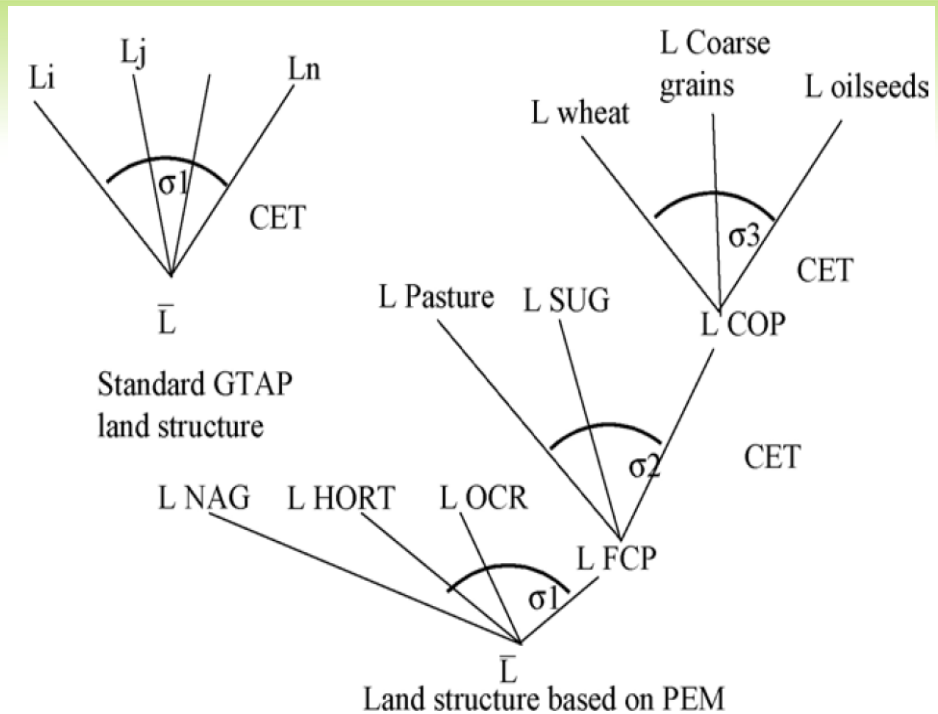
# IMPROVING ECONOMIC MODELS !

- ◎ **Intensification**
  - ◎ Different approaches
- ◎ **Land availability**
  - ◎ Marginal/unproductive lands
- ◎ **Co-products**
  - ◎ Some advances for ethanol DDGS (GTAP, EPPA)
- ◎ **Energy crops**
  - ◎ Some improvement for lignocellulosics (EPPA, LEITAP)
- ◎ **Bio-heat and bio-electricity pathways**
  - ◎ Some improvements in EPPA
- ◎ **Interaction between biofuel targets**
  - ◎ Some improvements in GTAP (EU+US mandates)
- ◎ **Disaggregation of products and regions**
  - ◎ Some improvements in FABRI (BR)

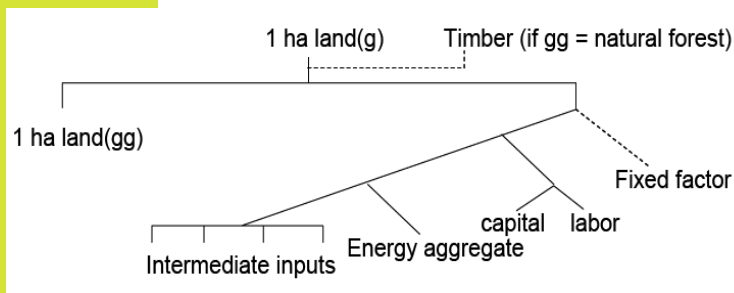
# IMPROVING ECONOMIC MODELS !

## Elasticities

- Yield/price responses
- Biofuels/Petroleum products
- Land transformation
- Trade
- Agricultural/biomaterial/energy markets



Land supply structure in LEITAP model: Based on PEM (OECD, 2003)



Land transformation function in the EPPA model (Gurgel et al., 2008)

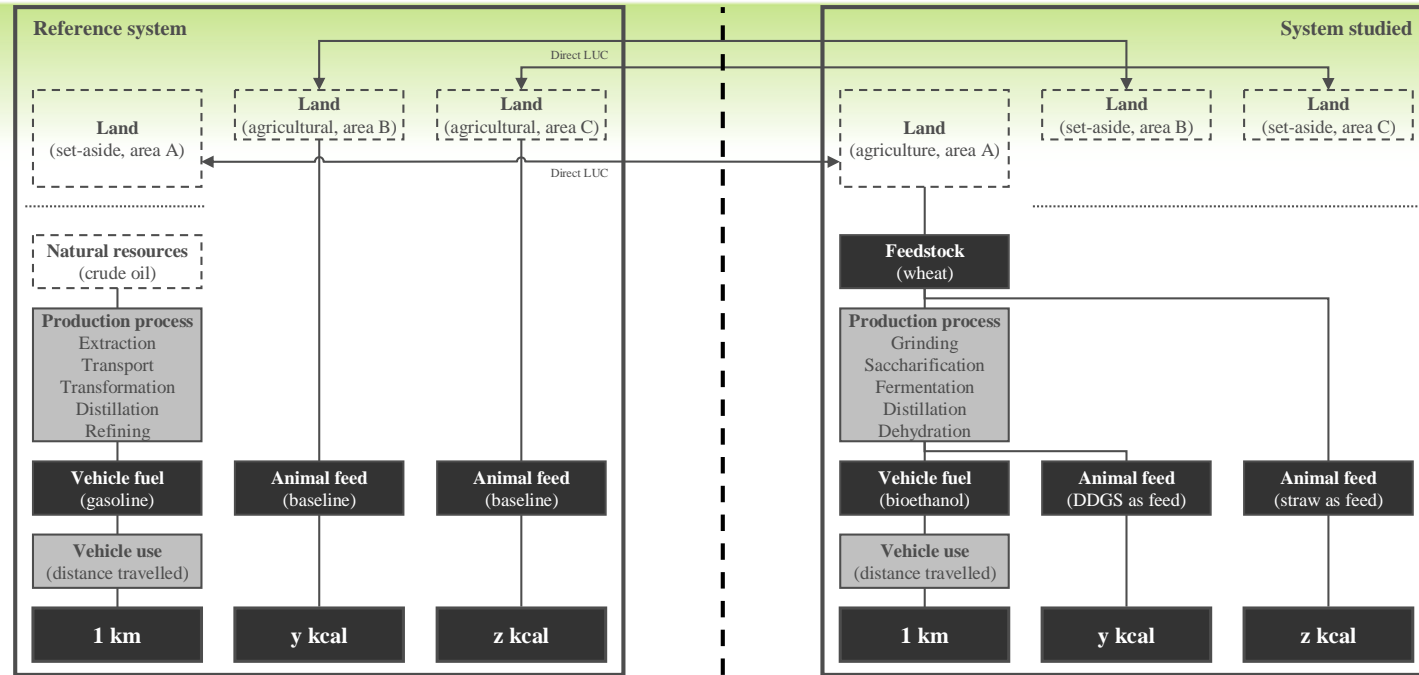


# IMPROVEMENTS ARE NOT ENOUGH ! WHAT ABOUT:

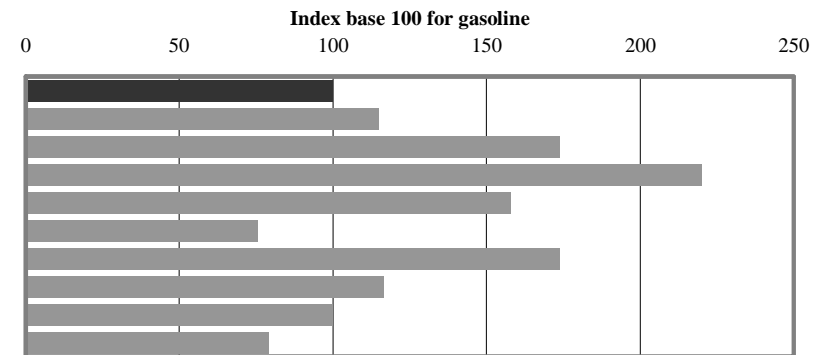
- ⊙ Sustainability regulations and other policies
- ⊙ Crops rotation/ management
- ⊙ Oligopoly and imperfect market conditions
- ⊙ Emergence of new biofuel producers and mandates
- ⊙ Selection of the biofuel feedstock
- ⊙ Actors' heterogeneity
- ⊙ The land owner choice/preferences

# UNCERTAINTIES IN LCA APPROACHES

- ⊙ **System boundaries**
  - ⊙ Alternative land-use
  - ⊙ Previous land-use
- ⊙ **Inputs**
  - ⊙ Average/marginal
  - ⊙ Conservative
- ⊙ **Reference system**
- ⊙ **Impact assessment methods**
  - ⊙ N2O emissions/Carbon stocks
  - ⊙ Aggregation
- ⊙ **Accounting for time**
  - ⊙ Discount rates



Allocation	LUC	Fuel	IPCC Index
-	-	<b>Gasoline</b>	<b>100.0</b>
A-2	LUC-1	Bioethanol	E-3 115.0
A-2	LUC-2	Bioethanol	E-3 173.7
A-2	LUC-3	Bioethanol	E-3 220.1
A-2	LUC-4	Bioethanol	E-3 157.8
A-2	LUC-5	Bioethanol	E-3 75.6
A-2	LUC-6	Bioethanol	E-3 173.7
A-2	LUC-7	Bioethanol	E-3 116.4
A-2	LUC-8	Bioethanol	E-3 99.8
A-2	LUC-9	Bioethanol	E-3 79.0



Gnansounou et al., 2008. Energy and GHG balance of Biofuels: Biases induced by LCA modelling choices

# RESEARCH NEEDS

- ◎ **Models integration**
  - ◎ Scale
  - ◎ Feedbacks
  
- ◎ **Alternative approaches**
  - ◎ System dynamics
  - ◎ Agent-based models
  
- ◎ **Down-scaling**
  - ◎ Spatial explicit models
  - ◎ National/Regional models
  
- ◎ **Impacts**
  - ◎ GHG emissions
  - ◎ Other categories
  
- ◎ **Models comparisons**
  
- ◎ **Policy**

# MODELS COMPARISONS: FRAMEWORK

## ◎ Some preliminar comparisons

- ◎ Witzke et al (2008)-Modelling of energy crops in agricultural sector models
- ◎ BPE (2008)-Background paper RSB Workshop on Biofuels and LUC
- ◎ JRC/EEA/OECD (2009)-Review and inter-comparison of modelling LUC effects of bioenergy

## ◎ Comparison methodology

- ◎ Common baseline
- ◎ Common scenarios
  - 2020, EU and US policies
- ◎ Explicit definition of inputs/parameters
  - Elasticities, Technology, Trade
- ◎ Standardization of results
  - Change in prices /crop/region, % of the diverted food/feed replaced by land, Categories of land changed)
- ◎ Uncertainty measure

**Outcome of JRC/EEA/OECD (January 2009)**

**Review and inter-comparison of modelling LUC effects of bioenergy**

# THE RED QUEEN PROBLEM

*“Now, here, you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!”*

- ◎ Biofuels development runs faster than models
- ◎ Impacts appears faster than policy control
- ◎ Need to take decisions today in spite of uncertainty
- ◎ Need to integrate science into policy



## ***A good example:***

California Environmental Protection Agency Air Resources Board  
Proposed Regulation to Implement the Low Carbon Fuel Standard -Volume I



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