Memo: **Report**[1] **on BUS ticket A21**
By: Frank van Tongeren and Marieke Meeusen, WUR- LEI
Date: February 12, 2005

BIOMASS ENERGY: EXPLORING POTENTIALS AND COMPETING RESOURCE CLAIMS

Definition of the problem
There seems to be a discrepancy between the results of the GRAIN study by the University of Utrecht, which suggest that wordl-wide there is enough land available both for the production of food and of biomass for energy and other researchers who doubt it. This quick-scan should give an idea about the area actually available

Questions
1.Which rearchers are involved in these kind of studies?
2.On which points do they fundamentally disagree with the results of the GRAIN study
3. What is needed to make a more reliable estimation of the area potentially available for biomass production?
4. Is an ecological cost-benefit analysis the right tool for such an assessment?
5. Which are the main assumptions and uncertainties?

Introduction

Renewable energy from biomass production is one option to create a more sustainable global energy economy in the long term. Production and consumption of biomass is driven by technical as well as economic considerations. Technical feasibility does not imply that new developments are actually taken into production, and long-term projections based purely on technological potential have time and again proven to be off-mark. The utilisation of biomass potential for (bio-) energy depends on a number of factors, including:

1. Agronomic features, including land availability and growing conditions
2. (supply) response of farmers, i.e. the decision to grow bio-energy relevant crops
3. Technical substitutability of biomass energy for conventional energy sources
4. Economic substitutability of biomass energy for conventional energy sources
5. National and global policies
6. Social considerations
7. Environmental considerations

Economists and economic models have something to say about items 2, 4 and 5 on the above (non-exhaustive) list. Agronomic, biophysical and technical aspects are typically included in these models in a cursory fashion. Agricultural economist, however, have a tradition in including agronomic production features into their models, and recent developments in the EU attempt integrated modelling of economic, agronomic, environmental, climatic and social issues. (e.g. SEAMLESS and SENSOR, which are both so-called integrated projects sponsored by the FP6 of the European Union).

Key to fruitful long-term projections of biomass issues is a proper modelling of the supply side of biomass and a proper representation of the demand side for bio-energy. In both

demand and supply, technical and economic considerations play a role, and therefore a multidisciplinary approach is warranted.

GTAP model

The GTAP modelling framework is a potentially a useful starting point, but it would need to be adapted for the specific issues at hand. The GTAP model is a global economy-wide model that covers worldwide production, consumption and trade. It is a general equilibrium model, based on the micro-economic foundations of production- and consumption behaviour. It captures backward and forward linkages within each of the regional economies through an input-output structure. In the general equilibrium structure both prices and quantities are endogenously determined as outcomes of the model after a perturbation of exogenous variables, such as policies, technological changes, taste changes etc..

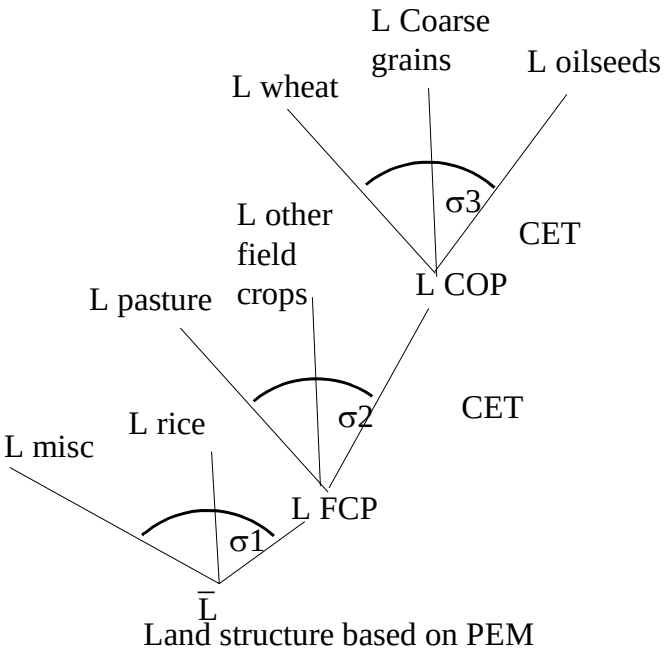
Since its inception in 1992, the explicit aim of the GTAP project has been the lowering of entry barriers to global trade analysis. The project is now supported by a consortium of 18 national and international agencies and provides financial support as well as guidance to the Center of Global Trade Analysis at Purdue University (USA). The consortium includes some of the major players in global trade analysis (World Bank, WTO, UNCTAD). The GTAP website provides more information on the consortium, conferences, courses and other activities and is a repository of resources: http://www.gtap.org/

Much of the focus of GTAP is directed towards the analysis of agricultural policy and trade, but there are also applications in non-agricultural trade-related issues as well as environmental policy analysis. More recently, database development and modeling have also expanded in the direction of energy usage and climate change. The current version of the database (version 6) has coverage of 87 regions, 57 commodity groupings and 5 primary factors (Land, Skilled and Unskilled Labour, Capital and Natural Resources), and is benchmarked to 2001 US dollar values. See Annex 1 for a country and commodity listing. The main components of the database consist of bilateral trade, transport and protection matrices that link the country/ regional input-output (IO) databases. Although the commodity coverage has a deliberate agricultural bias with 12 primary agricultural sectors (8 food processing sectors, 1 forestry sector and 1 fishing sector), within the remaining commodity groupings, there is significant disaggregation of manufacturing, services and fossil fuel sectors. The database contains energy use data for 5 energy commodities (coal, oil, gas, petroleum commodities, electricity), and a special model version (GTAP-E) is geared towards modeling energy and climate issues (this model has been used extensively in the IPCC context).

Given its current low share in global energy use, the database does not include separate information for biomass energy.

Modeling the supply side of biomass

A crucial aspect of modeling the supply of biomass crops is the allocation of land. In conjunction with the OECD secretariat, LEI has undertaken to model the agricultural supply side in GTAP in a specific way that allows us to capture the limited substitutability of land across alternative crops (and livestock for feeding purposes). In a nutshell, the land allocation is driven by relative returns that can be earned, while taking into account the fact that not all crops can easily be grown on alternative soils. The following figure illustrates the concept:

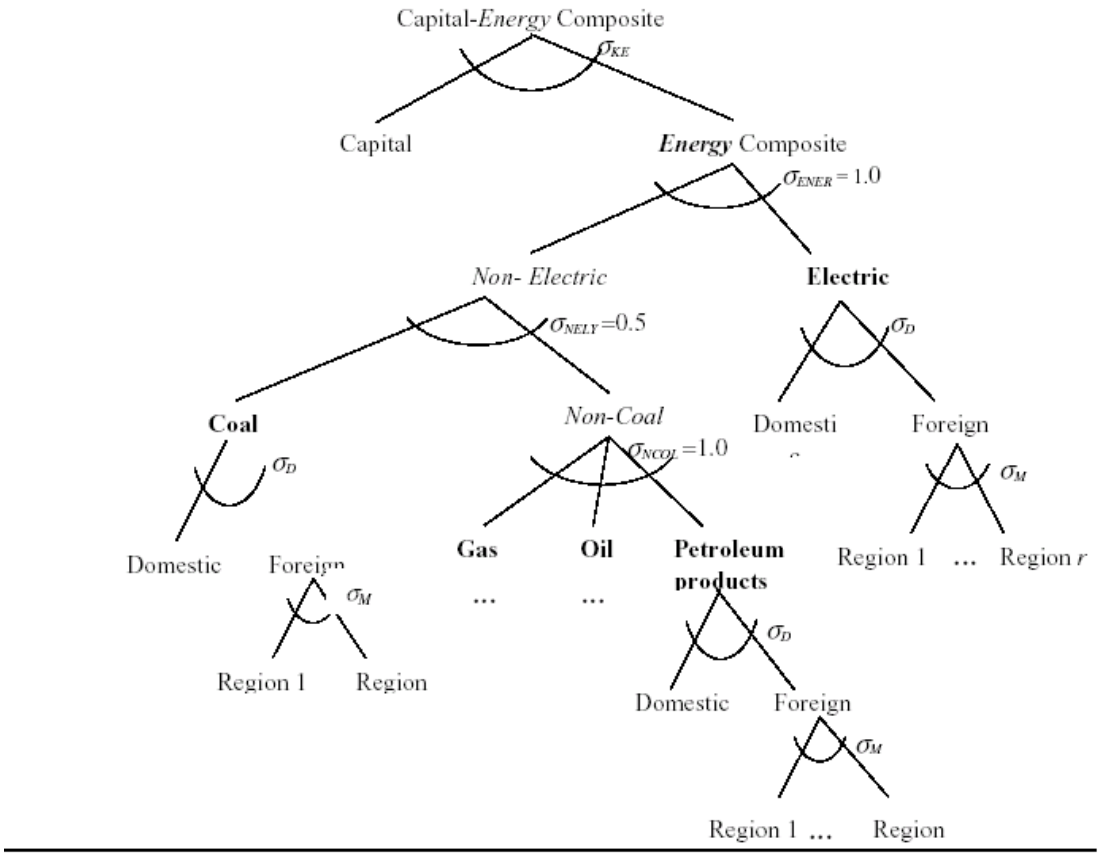


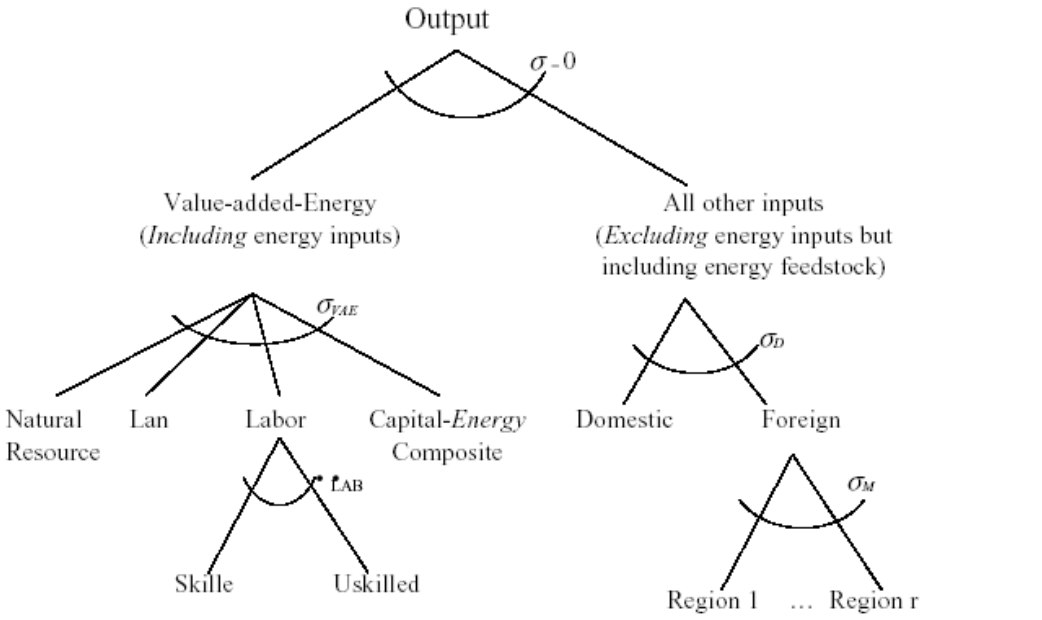
Land structure based on PEM

Total available land L is allocated over 3 broad 'nests'. Within each nest, the allocation is guided by constant elasticities of transformation σ_1, σ_2, σ_3. For example in the upper nest, land can easily be transformed between wheat, coarse grains and oilseeds (the COP complex), but it will require big shifts in relative returns to move land out of COPs and into pasture. In a way, alternative crops can be seen to compete about the available land resources. The relative returns of alternative uses depend on market returns and the policy setting.
Issues around trade offs between biomass and food security can easily be analyzed in this framework. The demand for food crops is derived from estimated demand functions that include relative prices and income and allow for varying expenditure shares as income grows.

Modeling the demand side for bio-energy
Energy modeling in GTAP already has a tradition, and as said above, we have a consolidated (i.e. consistent) database of conventional energy use. For energy modeling the substitution possibilities in demand amongst alternative energy sources is very important. This can be done in a variety of ways. The GTAP-E model proposes the approach pictured in the figure below, where the various σ now indicate elasticities of substitution. The users of energy decide their mix of sources on the basis of relative prices, including the domestic/foreign price ratio. If, for example, foreign electricity becomes cheaper, relative to domestic electricity, more will be imported. If this cheaper electricity import leads in addition to falling composite electricity sources, more electricity will be demanded relative to non-electric sources.
For bio-energy modeling, the biomass component would have to be folded into this structure.

Figure: Production structure GTAP-E





Where to go from here?

A very fruitful way of exploring future biomass potential is scenario analysis. We believe that an amended GTAP framework could be a very useful input in such a scenario analysis, and could indeed have a central role as a consistency framework.

Scenarios would evaluate contrasting visions of the future global economy, including amongst others the following driving forces:

- Global economic development (GDP growth)
- Population growth
- Policy developments, such as trade policy, agricultural policy, climate policies
- Consumer preferences wit regard to sustainable energy
- Technological assumptions on bio-energy

Development of scenarios should be a team effort, encompassing various disciplines, and in close cooperation with Shell.

Annex 1: GTAP region and sector detail

GTAP v6 commodity breakdown

Primary agriculture
Paddy rice
Wheat
Cereal grains nec
Vegetables, fruit, nuts
Oil seeds
Sugar cane, sugar beet
Plant-based fibers
Crops nec
Cattle,sheep,goats,horses
Animal products nec
Raw milk
Wool, silk-worm cocoons
Natural resource based activities
Forestry
Fishing
Coal
Oil
Gas
Minerals nec
Processing agriculture and food
Meat: cattle,sheep,goats,horse
Meat products nec
Vegetable oils and fats
Dairy products
Processed rice
Sugar
Food products nec
Beverages and tobacco products
Manufacturing
Textiles
Wearing apparel
Leather products
Wood products
Paper products, publishing
Petroleum, coal products
Chemical,rubber,plastic prods
Mineral products nec
Ferrous metals
Metals nec
Metal products
Motor vehicles and parts
Transport equipment nec
Electronic equipment
Machinery and equipment nec
Manufactures nec
Services
Electricity
Gas manufacture, distribution
Water
Construction
Trade
Transport nec
Sea transport
Air transport
Communication
Financial services nec
Insurance
Business services nec
Recreation and other services
PubAdmin/Defence/Health/Educat
Dwellings

GTAP v6 regions (87)	Member regions (226)
Austria	Austria
Belgium	Belgium
Denmark	Denmark
Finland	Finland
France	France
Germany	Germany
United Kingdom	United Kingdom
Greece	Greece
Ireland	Ireland
Italy	Italy
Luxembourg	Luxembourg
Netherlands	Netherlands
Portugal	Portugal
Spain	Spain
Sweden	Sweden
Bulgaria	Bulgaria
Cyprus	Cyprus
Czech Republic	Czech Republic
Hungary	Hungary
Malta	Malta
Poland	Poland
Romania	Romania
Slovakia	Slovakia
Slovenia	Slovenia
Estonia	Estonia
Latvia	Latvia
Lithuania	Lithuania
Rest of Oceania	American Samoa
	Cook Islands
	Fiji
	French Polynesia
	Guam
	Kiribati
	Marshall Islands
	Micronesia, Federated States of
	Nauru
	New Caledonia
	Norfolk Island
	Northern Mariana Islands
	Niue
	Palau
	Papua New Guinea
	Samoa
	Solomon Islands
	Tokelau
	Tonga
	Tuvalu
	Vanuatu
	Wallis and Futuna
India	India
Rest of Free Trade Area of the Americas	Antigua & Barbuda
	Bahamas
	Barbados

	Dominica
	Dominican Republic
	Grenada
	Haiti
	Jamaica
	Puerto Rico
	Saint Kitts and Nevis
	Saint Lucia
	Saint Vincent and the Grenadines
	Trinidad and Tobago
	Virgin Islands, U.S.
Rest of the Caribbean	Anguilla
	Aruba
	Cayman Islands
	Cuba
	Guadeloupe
	Martinique
	Montserrat
	Netherlands Antilles
	Turks and Caicos
	Virgin Islands, British
Rest of South African Customs Union	Lesotho
	Namibia
	Swaziland
Malawi	Malawi
Tanzania	Tanzania, United Republic of
Zimbabwe	Zimbabwe
Rest of Southern African Development Community	Angola
	Congo, the Democratic Republic of the
	Mauritius
	Seychelles
Madagascar	Madagascar
Uganda	Uganda
Rest of Southeast Asia	Brunei Darussalam
	Cambodia
	Lao People’s Democratic Republic
	Myanmar
	Timor Leste
Bangladesh	Bangladesh
Rest of South Asia	Afghanistan
	Bhutan
	Maldives
	Nepal
	Pakistan
Mozambique	Mozambique
Zambia	Zambia
Rest of Sub-Saharan Africa	Benin
	Burkina Faso
	Burundi
	Cameroon
	Cape Verde
	Central African Republic
	Chad
	Comoros
	Congo
	Cote d'Ivoire

	Djibouti
	Equatorial Guinea
	Eritrea
	Ethiopia
	Gabon
	Gambia
	Ghana
	Guinea
	Guinea-Bissau
	Kenya
	Liberia
	Mali
	Mauritania
	Mayotte
	Niger
	Nigeria
	Reunion
	Rwanda
	Saint Helena
	Sao Tome and Principe
	Senegal
	Sierra Leone
	Somalia
	Sudan
	Togo
Brazil	Brazil
Botswana	Botswana
South Africa	South Africa
United States of America	United States of America
New Zealand	New Zealand
Japan	Japan
Korea	Korea, Republic of
Canada	Canada
Mexico	Mexico
Switzerland	Switzerland
Rest of EFTA	Iceland
	Liechtenstein
	Norway
China	China
Russian Federation	Russian Federation
Turkey	Turkey
Rest of Middle East	Bahrain
	Iran, Islamic Republic of
	Iraq
	Israel
	Jordan
	Kuwait
	Lebanon
	Palestinian Territory, Occupied
	Oman
	Qatar
	Saudi Arabia
	Syrian Arab Republic
	United Arab Emirates
	Yemen
Morocco	Morocco

Tunisia	Tunisia
Rest of North Africa	Algeria
	Egypt
	Libyan Arab Jamahiriya
Indonesia	Indonesia
Australia	Australia
Thailand	Thailand
Hong Kong	Hong Kong
Taiwan	Taiwan
Rest of East Asia	Macau
	Mongolia
	Korea, Democratic People's Republic of
Malaysia	Malaysia
Philippines	Philippines
Singapore	Singapore
Viet Nam	Viet Nam
Sri Lanka	Sri Lanka
Rest of North America	Bermuda
	Greenland
	Saint Pierre and Miquelon
Colombia	Colombia
Peru	Peru
Venezuela	Venezuela
Rest of Andean Pact	Bolivia
	Ecuador
Argentina	Argentina
Chile	Chile
Uruguay	Uruguay
Rest of South America	Falkland Islands (Malvinas)
	French Guiana
	Guyana
	Paraguay
	Suriname
Central America	Belize
	Costa Rica
	El Salvador
	Guatemala
	Honduras
	Nicaragua
	Panama
Rest of Europe	Andorra
	Bosnia and Herzegovina
	Faroe Islands
	Gibraltar
	Macedonia, the former Yugoslav Republic of
	Monaco
	San Marino
	Serbia and Montenegro
Albania	Albania
Croatia	Croatia
Rest of Former Soviet Union	Armenia
	Azerbaijan
	Belarus
	Georgia
	Kazakhstan
	Kyrgyzstan

Moldova, Republic of
Tajikistan
Turkmenistan
Ukraine
Uzbekistan