Economics and Environmental Impacts of Ligno-Bioethanol Fuel

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Introduction

Biofuels:

Panacea or ecological (and society’s) threat?

+ Important contribution to reduce environmental impact of mobility (CO₂, resources)
- Competition for biomass (environmental stress, “tortilla clashes”)

“Smarter” biofuels
e.g. lignocellulosic bioethanol
Objective

Comparison of *food-based bioethanol* with *ligno-bioethanol* exemplarily for Germany

- Market penetration
- Environmental impacts (Carbon dioxide)

### Market penetration

#### Switchgrass
(Source: www.nrel.gov/biomass/photos.html)

#### Corn stover
(Source: www.nrel.gov/biomass/photos.html)
Processing of bioethanol

Food-based bioethanol
- Corn
- Sugar cane
- Wheat

Ligno-bioethanol
- Straw
- Miscanthus
- Jerusalem artichoke

Source: www.bayertechnology.com
Model

- Markets/Processes (stylized)

  "Bio-energy" processes
  - Biodiesel 4
  - Bioethanol 13
  - BtL 5
  - Biogas 9

  "Non-Bio-energy" processes
  - Agriculture 35
  - Food 6
  - Wood & paper 10
  - Fossil-based 9

- Technico-economic model
- Final demand-driven

- Geographical system boundary:
  - by German customer induced demand
- Base year: 2005
- Final year: 2020
Scenario ~ Business as usual

- Costs
  - Labour, overhead, non-energy equipment: + 1.5 % p.a.
  - Crude oil price: exogenous: 60 $/bbl, 80 $/bbl, 100 $/bbl, 120 $/bbl (in 2020); Exchange rate: 1.2 $/€
  - Prices of fossil-based resources (gas, coal): follow crude oil price
  - All other costs: endogenous

- Final demand: change between 2005 and 2020
  - Food - 5.1 % to + 6.1 %
  - Paper & wood products + 24.6 %
  - Fuels
    - Gasoline - 37.8 %
    - Diesel - 10.9 %
    - Gas + 825.0 %
  - Power & heat - 0.5 %

Sources: Uihlein (2006), MWV (2006), EWI/Prognos (2005), and own assumptions and calculations
Scenario ~ Business as usual

- Energy policy:
  Implementation of currently known plans and bills
  But: Taxation of the heat value

- Agricultural policy:
  Implementation of the European CAP reform

- Foreign trade policy:
  no change

Regulations of fuels in the model

- Quota system (Blending of fossil fuels): Biogenic share
  - at total sale of gasoline and diesel: 8.0 % (heat value)
  - at sale of gasoline: 3.6 % (heat value)
  - at sale of diesel: 4.4 % (heat value)

- Taxation (no tax breaks):
  - Gasoline: 65.45 ct/l  Bioethanol: 42.43 ct/l
  - Fossil diesel: 47.04 ct/l  Biodiesel: 42.97 ct/l
  - BtL: 43.91 ct/l
Market for bioethanol

- Increasing crude oil price promotes bioethanol
- Ligno-bioethanol profits from a rising crude oil price disproportionately high
Environmental impacts

System boundary?

Land clearing → Cultivation → Processing → Use

“Typical” system boundary

System boundary with land use change

Relevance of land use change (LUC): LUC induced CO₂ emissions are about 17 to 420 higher than annual emission reductions by biofuel use (Fargione et al. 2008)
Carbon stock change due to LUC

Carbon stock change in Germany, for selected land use categories, w/o liming, average 1990-2007

Source: own calculation based on NIR Germany 2009

Sugar cane induced carbon stock change in Brazil, for selected land use categories

Carbon dioxide emission factors

![Graph showing carbon dioxide emission factors for different ligno-bioethanol feedstocks. The x-axis represents different feedstocks: Wheat, Straw, Sugar cane, Switchgrass, Jerusalem artichoke, Miscanthus, and Poplar. The y-axis represents carbon dioxide emission factors in units of grams CO₂ per gram BioEtOH. Different bars indicate whether there is land use change or not, with distinct colors for each category.](image-url)
A high crude oil price depresses the carbon dioxide emissions of bioethanol.

At a high crude oil price food-based bioethanol seems to be advantageous.
Conclusions

Markets

- Increasing crude oil price promotes bioethanol
- Ligno-bioethanol profits from a rising crude oil price disproportionately high
- But,
  - pre-condition: saleable production processes
  - precise knowledge of these saleable production processes
Conclusions

Environment (Carbon dioxide)

- A high crude oil price depresses the carbon dioxide emissions of bioethanol
- At a high crude oil price food-based (i.e. sugar cane based) bioethanol seems to be advantageous
- But, the environmental impact depends on the
  - market success of a process route
  - origin of the feedstock
  - knowledge of carbon disposal due to land use change has to be improved
W.R. Poganietz | Ligno-Bioethanol KIT – die Kooperation von Forschungszentrum Karlsruhe GmbH und Universität Karlsruhe (TH)

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