

Combined Biogas and Ethanol Production

Anton Friedl

Vienna University of Technology, Austria

[*afriedl@mail.zserv.tuwien.ac.at](mailto:afriedl@mail.zserv.tuwien.ac.at)



TECHNISCHE
UNIVERSITÄT
WIEN
VIENNA
UNIVERSITY OF
TECHNOLOGY

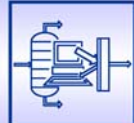
Combined Biogas and Ethanol Production
A. Friedl - IEA Task 39 - 09.09.2008

INSTITUTE OF
CHEMICAL
ENGINEERING
THERMAL PROCESS
ENGINEERING &
SIMULATION



Content

- Introduction - Motivation
- Modelling - IPSEpro
 - Bio-ethanol Production
 - Biogas Production
 - Straw Combustion
- Results
 - Heat and mass balance
 - Biogas production and utilisation
 - Straw Combustion
 - Sustainability of small scale and large scale plants
 - Economy of small scale plants
- Summary

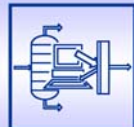
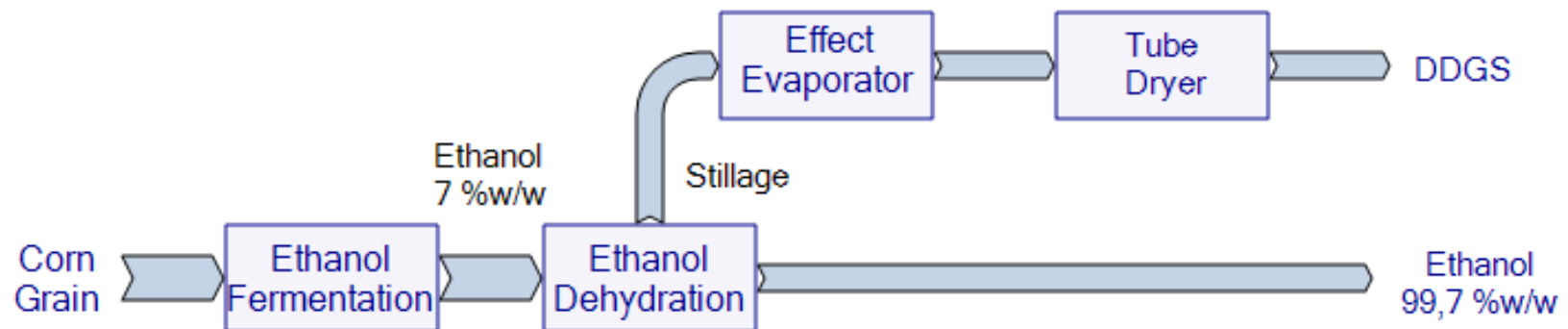


Motivation – Integrated Polygeneration

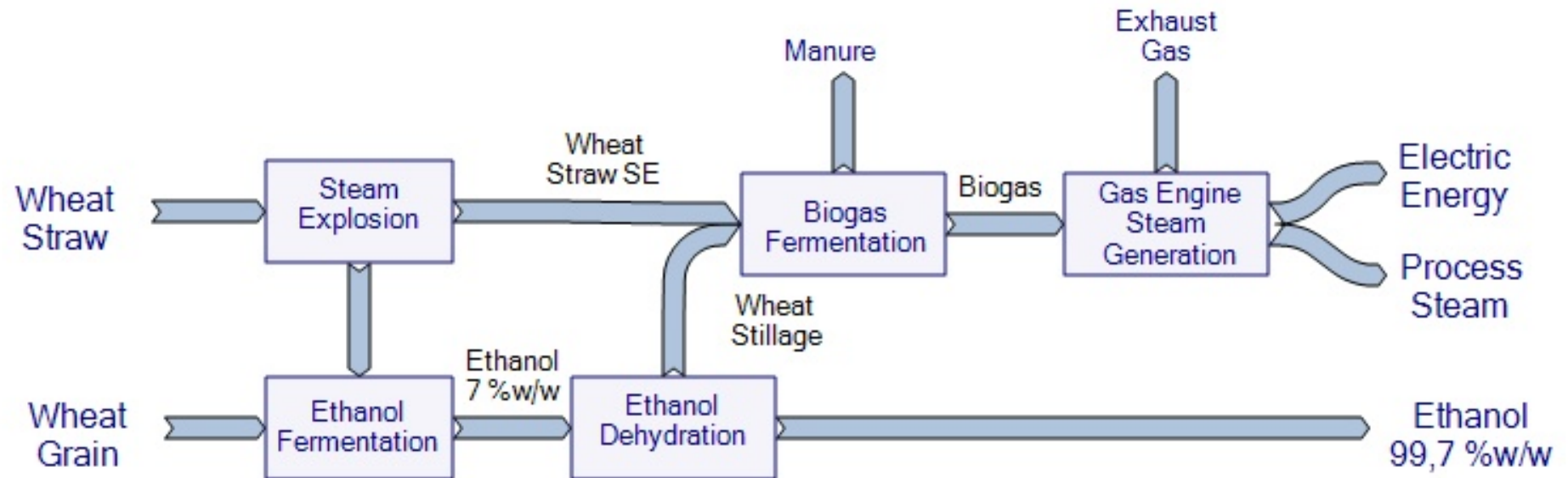
- Bio-ethanol production
 - Sustainable Energy Sources
 - NO fossil fuels for the process
 - Substrate from Starch/Sugar to Lignocellulosic
- Biogas + CHP production
 - Excellent Power production efficiency even at relative small scale
 - Waste heat problem
- Bio-ethanol production in combination with Biogas production + CHP (or Methane enrichment)
 - Production of Ethanol, Heat (Steam), Electric Power and By-Products (con. Biogas, Fertilizer)



Ethanol Production – Standard



Sustainable Ethanol Production

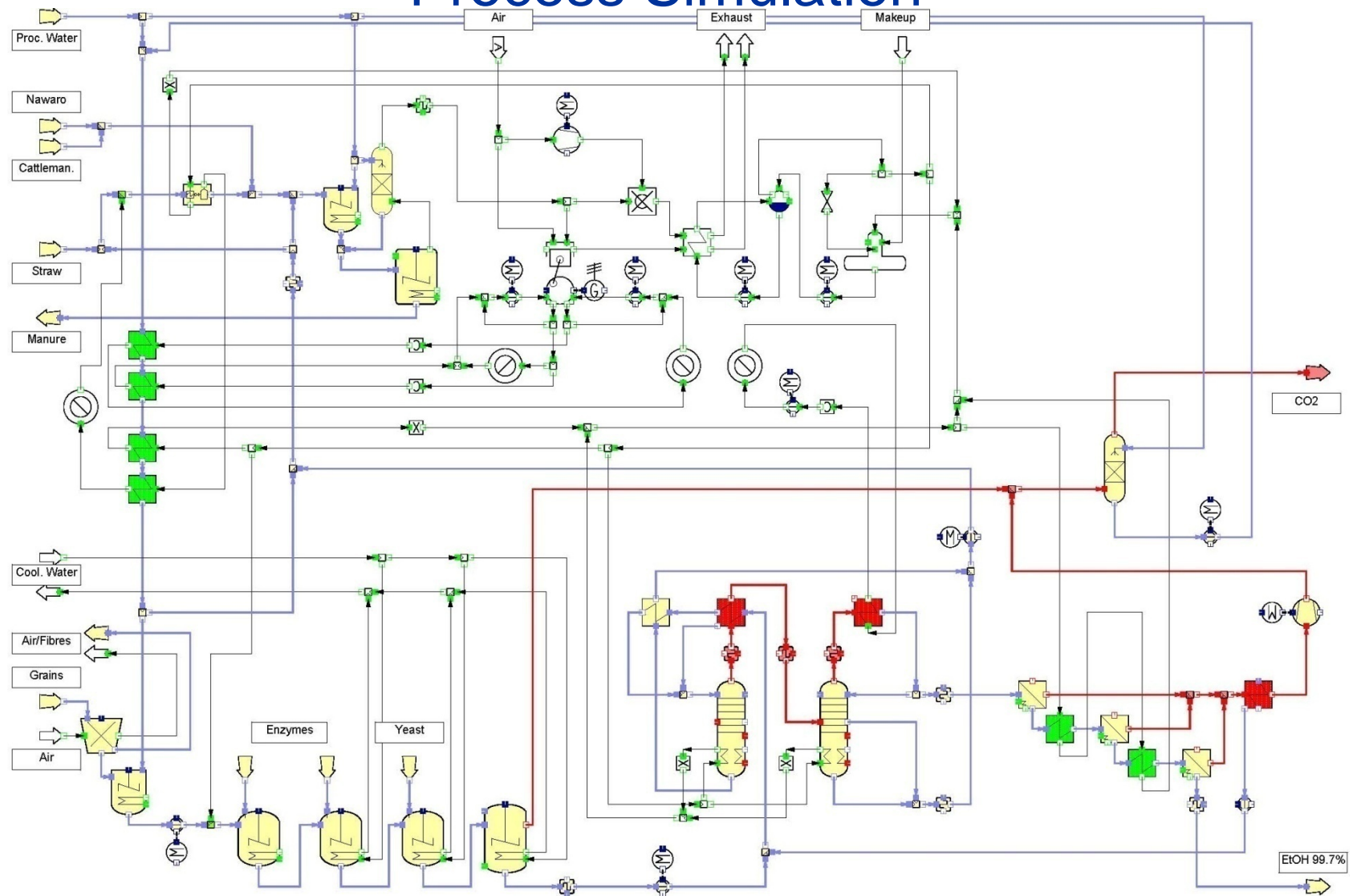


Boundary Conditions for the Study

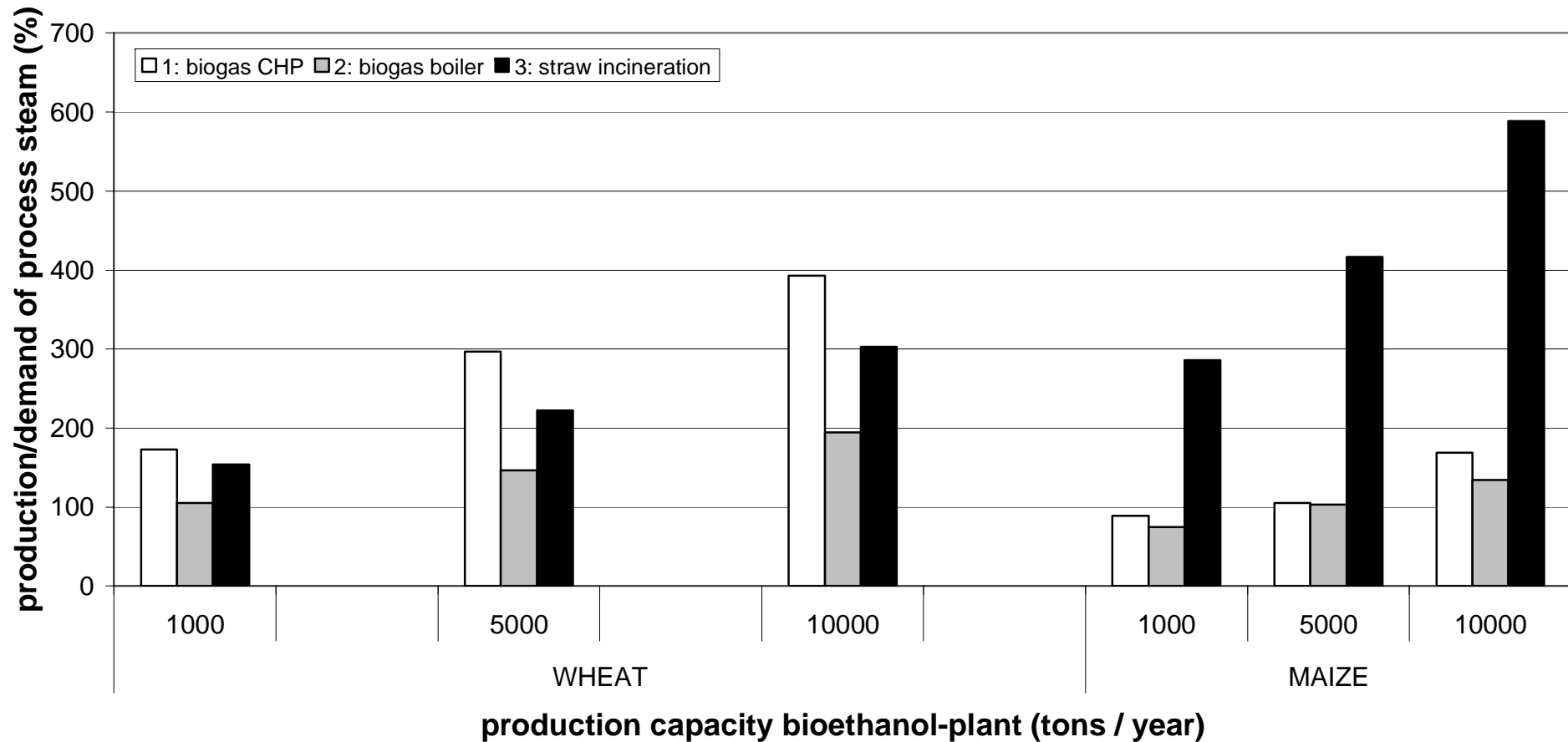
- Feedstock for bioethanol production
 - Wheat and Maize, Straw
- Investigated Plant Size
 - 1.000 / 5.000 / 10.000 t/a Bio-ethanol
- Investigated Facilities
 - Bio-ethanol Production
 - Biogas Production and CHP (Option 1)
 - Biogas Production and gas fired boiler (Option 2)
 - Straw Combustion (Option 3)
- Combination of different Feedstocks, Plant Sizes and Facilities during Simulation
- Main target – Energy self supply
- Biogas residues recycled to the fields



Process Simulation



Results – Heat Demand/Production



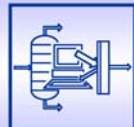
Ref.: Friedl et al; 15th European Biomass Conference & Exhibition, 7-11 May 2007, Berlin, Proc. P 1891-1894

Results – Option 3 Straw Incineration

Required percentage of straw for 100 % coverage of bioethanol plants' energy demand by straw incineration, based on total amount of wheat/maize straw available from grain cultivation

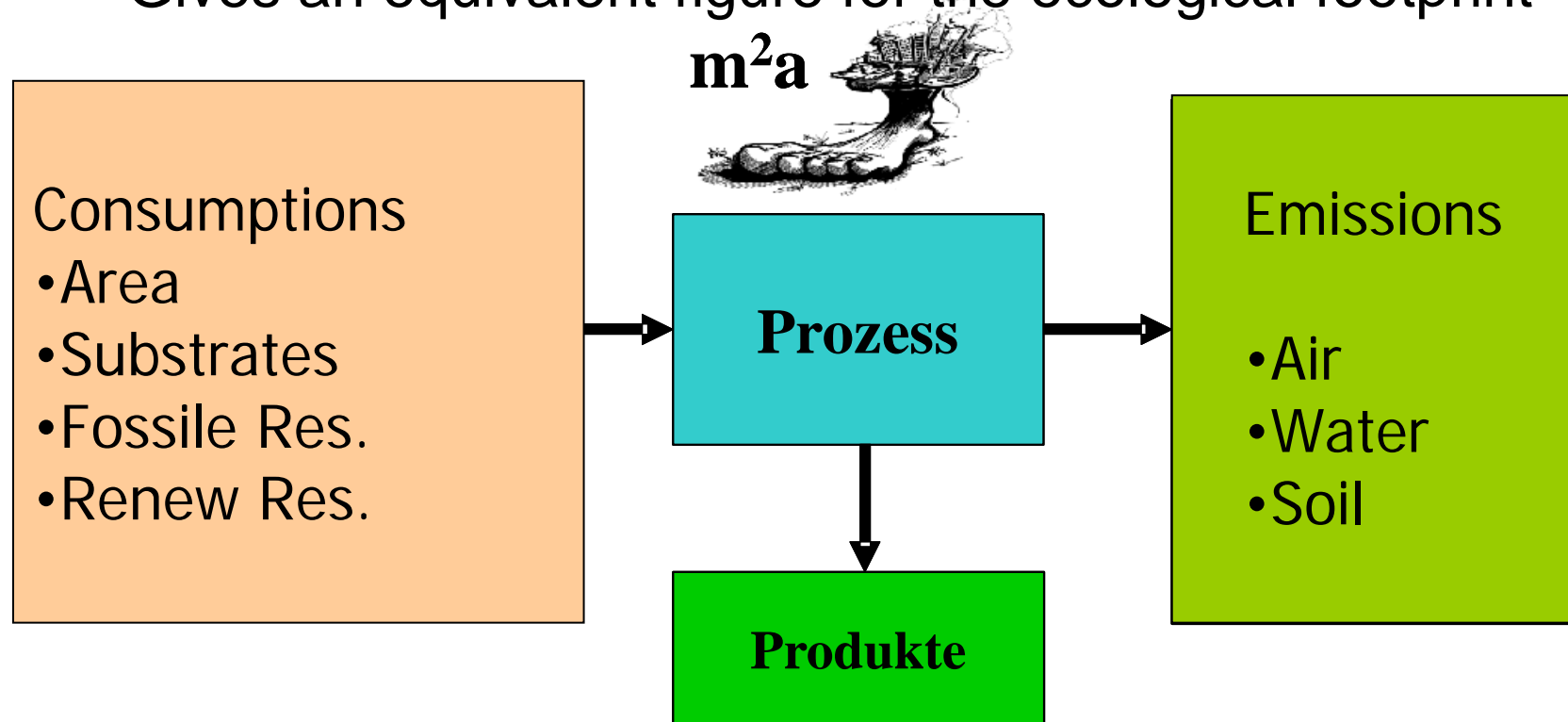
bioethanol feedstock	wheat				maize	
bioethanol plant capacity (t/y)	1000	5000	10000	1000	5000	10000
total straw available (t/y)	3240	15739	30604	5828	28310	55047
straw to cover energy demand (%)	49	34	24	26	18	13

Ref.: Friedl et al; 15th European Biomass Conference & Exhibition, 7-11 May 2007, Berlin, Proc. P 1891-1894



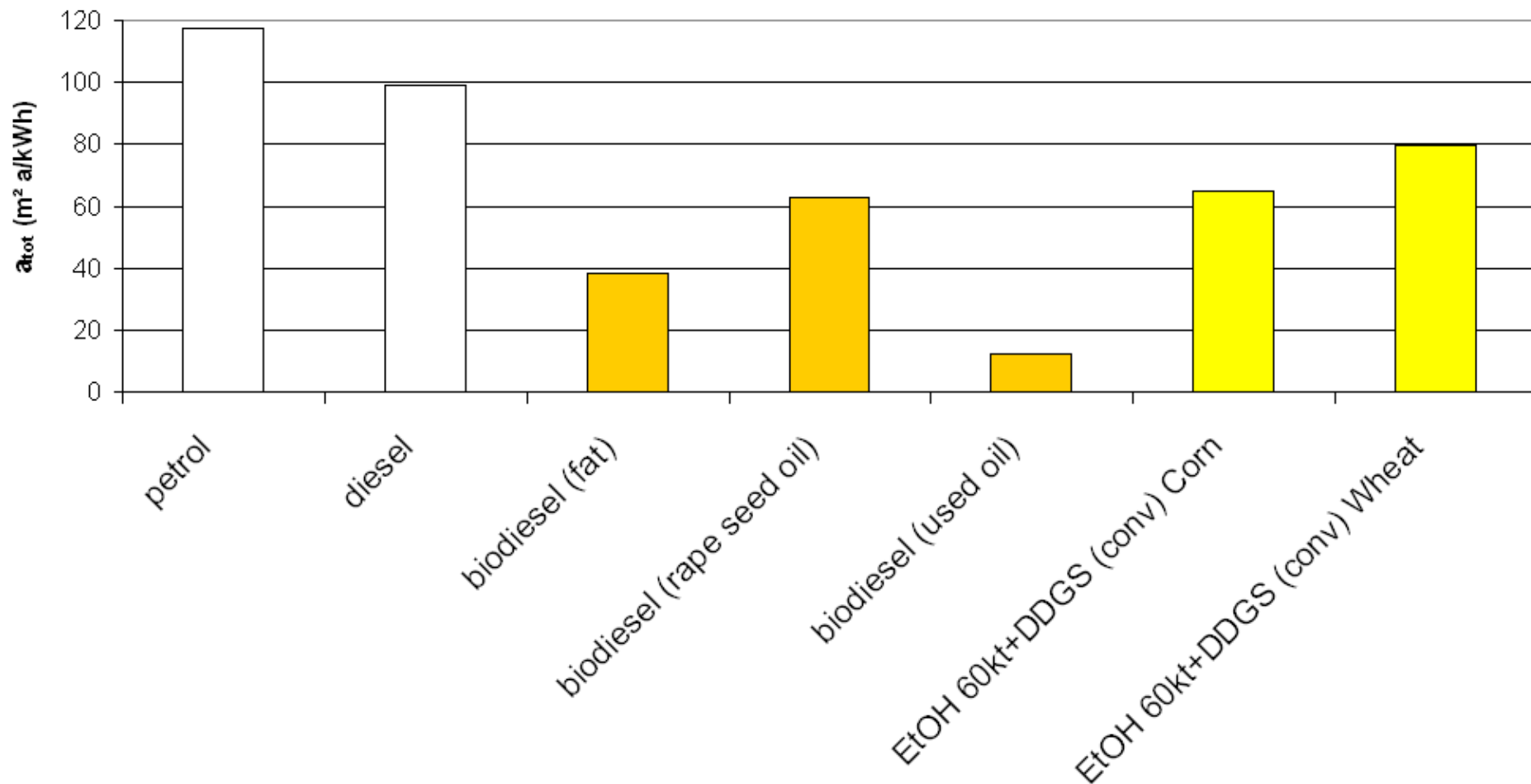
Biofuels-Environmental Aspects

- SPI (sustainable process index) concept
- Gives an equivalent figure for the ecological footprint

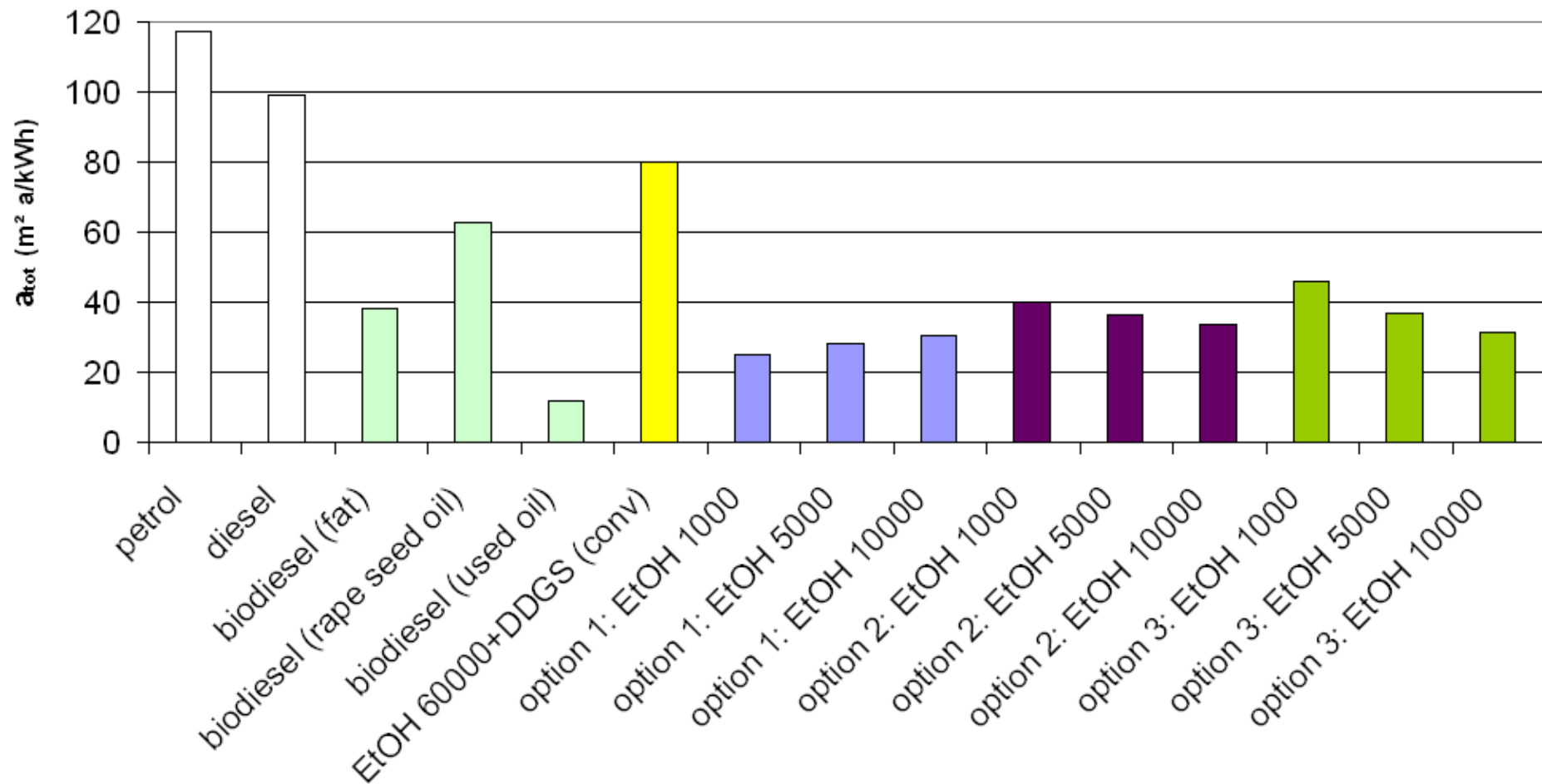


SPIonExcel, v 2.0, Graz University of Technology, Graz, 2006, <http://spionexcel.tugraz.at>

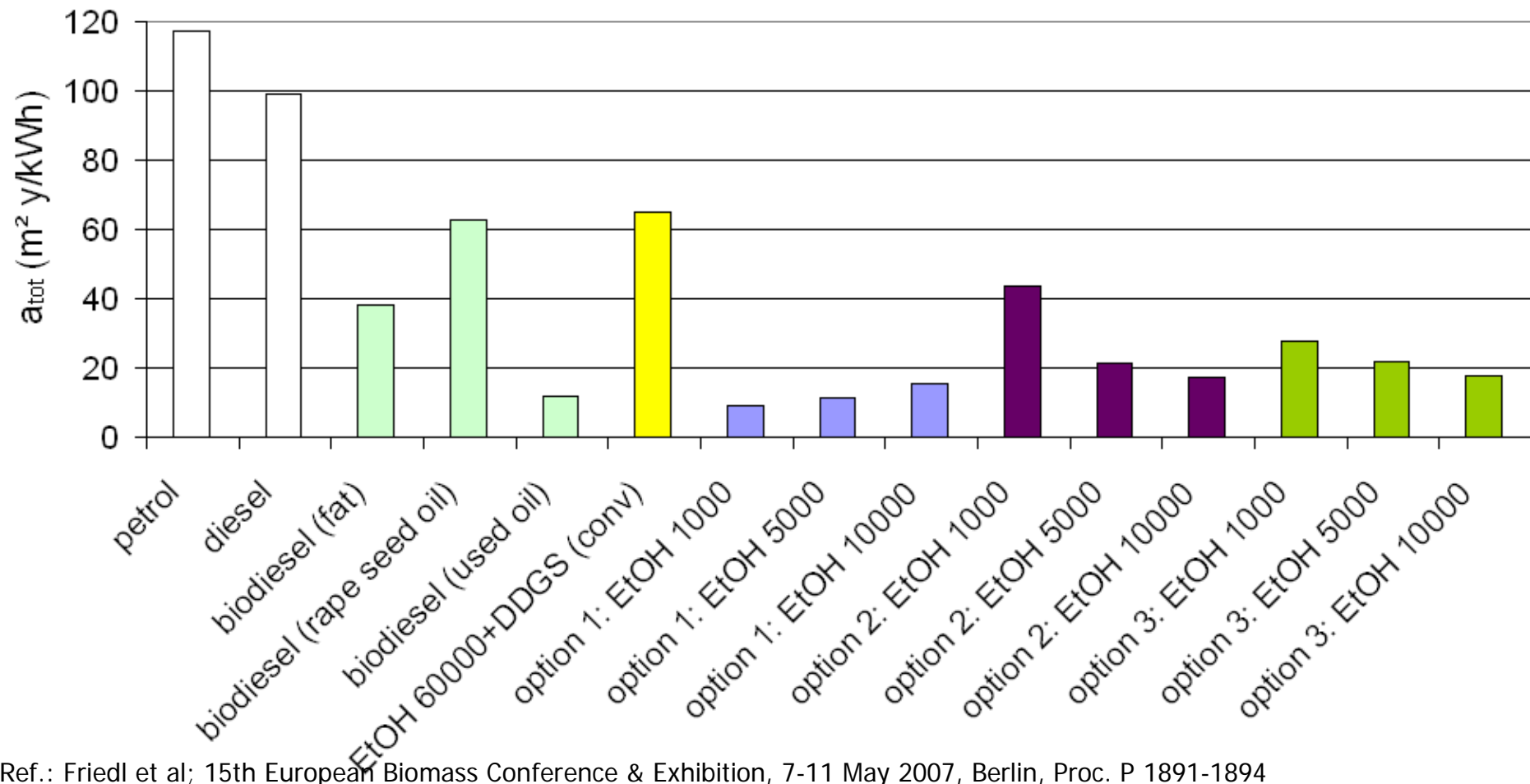
SPI of Large Scale Plants – Powered by Fossile Fuels



SPI of Small-Scale Ethanol Process - Wheat



SPI of Small-Scale Ethanol Process - Maize



Ref.: Friedl et al; 15th European Biomass Conference & Exhibition, 7-11 May 2007, Berlin, Proc. P 1891-1894

Simulation-Tool IPSE Economy Tool

IPSEpro-PSEconomy - Vorlage BioethanolEdZ2_20061024.iaa

File Edit View Calculation Investment Operation Economic Analysis Optimization Help

Vorlage BioethanolEdZ2_20061024

- General
 - Schedule
 - Monetary Info
 - Discount Rate
 - Taxation
 - PSE Link
- Investment
 - Financing
 - Construction
 - Total Capital Investment**
- Operation
 - Master Sheets
 - Years
 - Operation Summary
- Economic Analysis
 - Costs & Revenues Definitions
 - Annual Results
 - Profitability Assessment

Description	Value	Status
Total Capital Investment	909,663.92	output
Fixed capital investment (FCI)	884,380.00	output
Fixed capital investment without Contingencies (FCI w/o CO)	884,380.00	output
Direct Costs (DC)	884,380.00	output
Technical Equipment	499,000.00	output
Rohstoffaufbereitung	8,000.00	Custom Value
Anmischung	18,000.00	Custom Value
Verzuckerung	36,000.00	Custom Value
Fermentation	140,000.00	Custom Value
Destillation, Rektifikation	283,000.00	Custom Value
Eindampfung	14,000.00	Custom Value
Other Equipment	85,380.00	output
Getreidelager	62,000.00	Custom Value
Kühltürme	7,000.00	Custom Value
Alkohollager	16,380.00	Custom Value
Buildings	230,000.00	Custom Value
Land (Land)	70,000.00	Custom Value
Indirect Costs (IC)	0.00	output
Engineering and Supervision (ES)	0.00	not configured
Construction Costs (COCO)	0.00	not configured
Contingencies (CO)	0.00	not configured
Other Outlays	25,283.92	output
Startup Costs (SUC)	0.00	not configured
Working Capital (WC)	0.00	not configured
Costs for licensing, research and development (LDR)	0.00	not configured
Allowance for funds used during construction (AFUDC)	25,283.92	output
Salvage Value of Property	0.00	not configured

Cost Element: Land (Land)

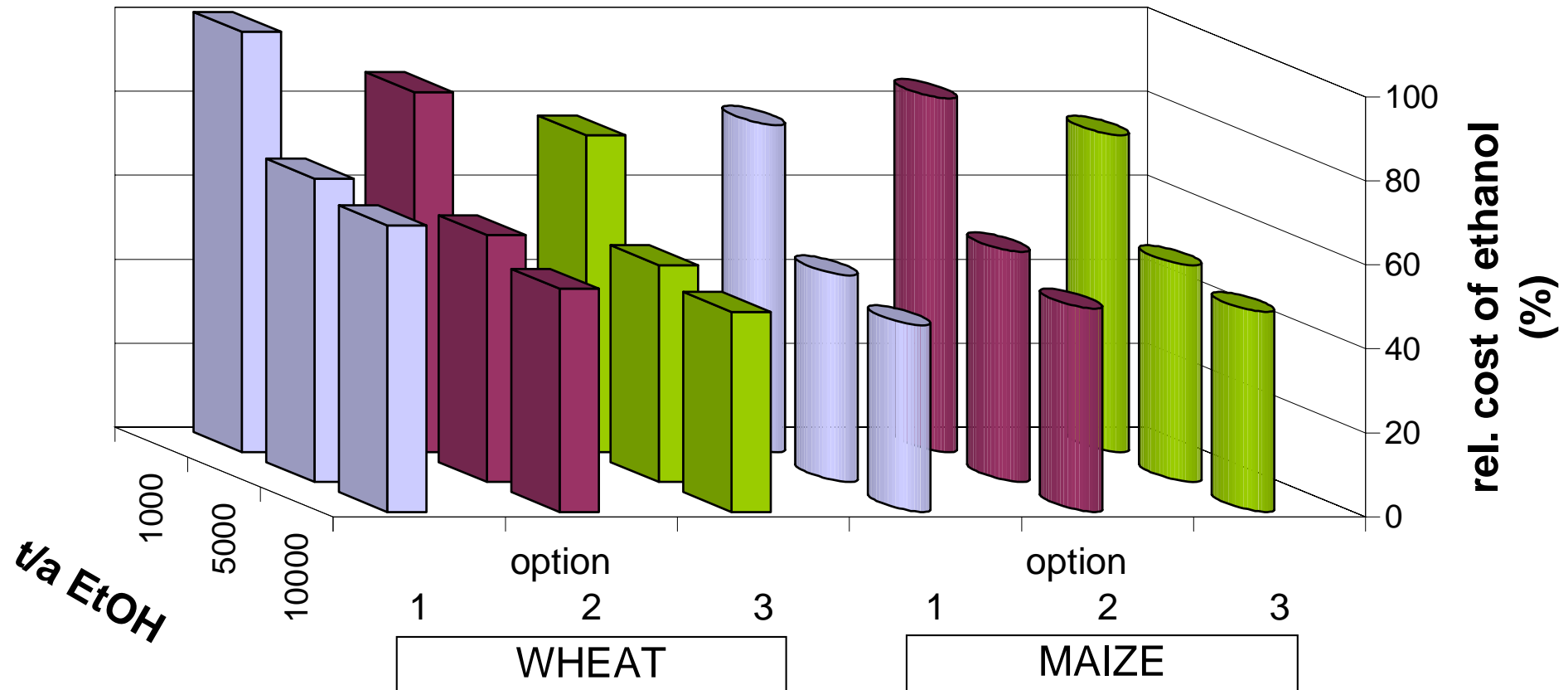
Obtain value: ☐ from PSE item ☐ as percentage of cost element ☒ from fixed direct input

Item: 70,000.00

Configure >>

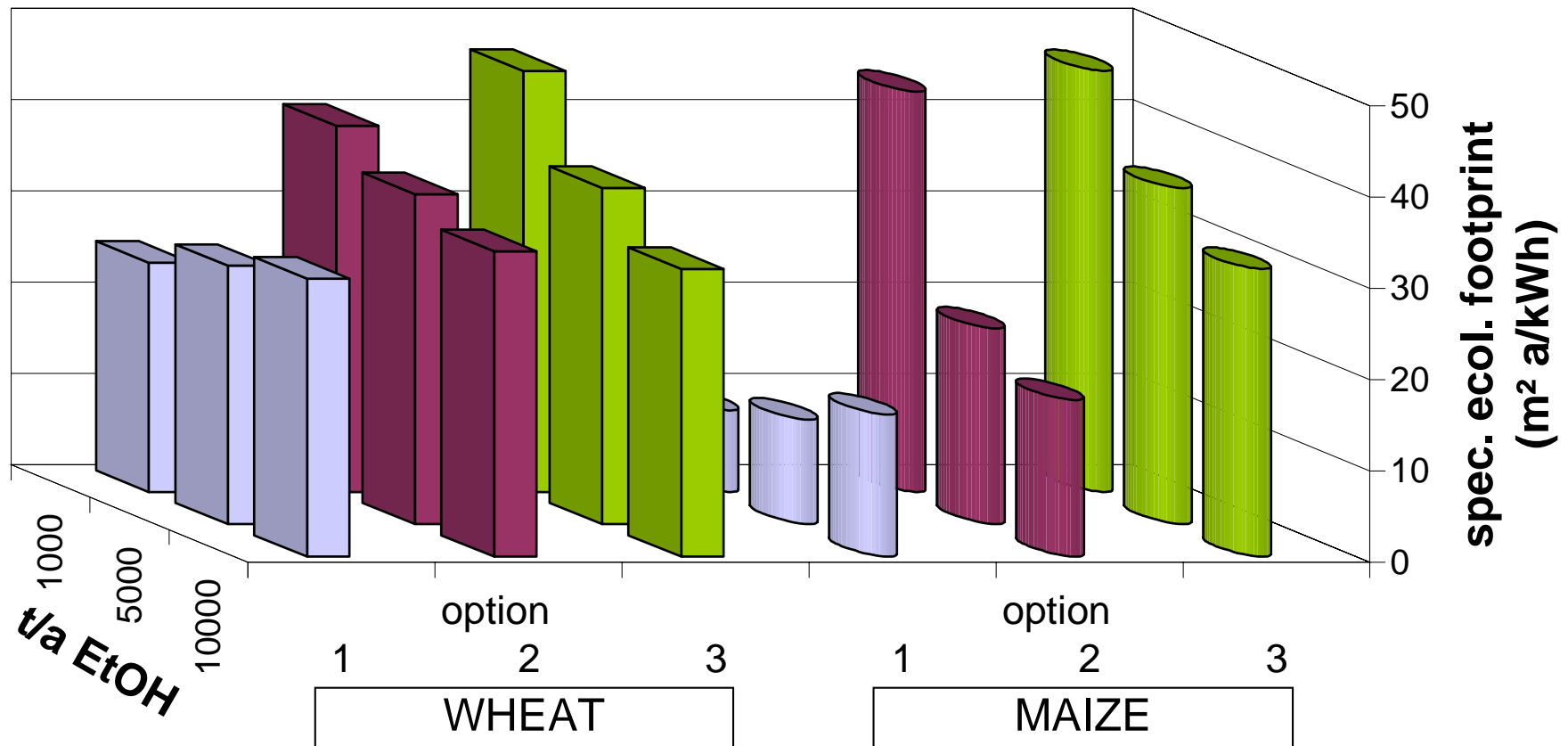
Ready

Economic Analysis



Ref.: Friedl et al; 16th European Biomass Conference & Exhibition, 2-6 June 2008, Valencia, Proc. In preparation

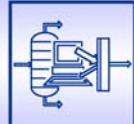
Ecologic Analysis



Ref.: Friedl et al; 16th European Biomass Conference & Exhibition, 2-6 June 2008, Valencia, Proc. In preparation

Summary

- Bio-ethanol production by use of renewable energy from by-products of feedstock and/or combination with biogas production can cover 100% of energy needed
- Specific ecological footprint of bio-ethanol can be reduced up to 10% of the fossil fuels
- Partial combustion of straw from feedstock production covers heat demand in all cases of small ethanol facilities (even drying of DDGS would be possible) in option 3
- High potential in the local integration of small scale plants (feedstock – residues)
- Costs optimization for small-scale bio-ethanol plants combined with biogas plants leads to a compromise between economical and ecological aspects
- Further proof of concept with lignocellulosic feedstock is under investigation



Acknowledgement

We gratefully acknowledge the support of the project by the Austrian Federal Ministry of Transport, Innovation and Technology – Energy Systems of the Future (Project-Nr. 807764, 811262 and 813593).

