

GREEN FUELS – SUSTAINABILITY CRITERIA APPLIED TO HYDROGEN, BIOFUELS AND ELECTRICITY FOR TRANSPORTATION

Matthias Altmann, Werner Weindorf, Patrick R. Schmidt, Christoph Stiller

Author affiliation:

Ludwig-Bölkow-Systemtechnik GmbH (LBST)
Daimlerstrasse 15, 85521 Munich-Ottobrunn, Germany
Altmann@LBST.de

EXTENDED ABSTRACT

Sustainability criteria for biofuels for transport and for stationary use are becoming legal requirements in the European Union. A systematic structure of sustainability criteria developed by the authors (Fig. 1) facilitates the comparison of legal and voluntary criteria catalogues. Results presented here on the major sustainability criteria discussed widely in public and among experts show that the hopes presently put on biofuels are exaggerated and pose serious environmental and social risks. Electricity and hydrogen as transport fuels can achieve full sustainability goals if based on renewable electricity.

Greenhouse gas emissions

Greenhouse gas reductions of biofuels, hydrogen and electricity have large bandwidths. A 100% reduction is feasible if renewable power or suitable biomass pathways are used. Unfavorable biomass pathways provide significant increases in GHG emissions compared to oil-based fuels (Fig. 2 based on analyses by the authors (JEC, 2007)).

Land use

Hydrogen and renewable electricity require significantly less land area than any biofuel production pathway, which often strongly compete with food production. Renewable electricity and hydrogen production can use land that is not suitable for food production or allows for co-existence with agriculture (Fig. 3 and Fig. 4). The biofuels potential in the EU is hardly sufficient to meet the European biofuels target for 2010 of 5.75% (Fig. 5 and Fig. 6). Yield and potential analyses are based on detailed analyses carried out by the authors (Weindorf & Altmann, 2007), (JEC, 2007), (VES, 2007). Because of competition with stationary energy uses only 50% of the technical potentials may be available for transport. Around 50% of the land area of Africa would be required to substitute today's global mineral oil consumption by palm oil (compared to 7% arable land in Africa), while hydrogen from photovoltaics would only require 5-6%.

Water intensity

Analyses based on average or typical values of water requirements show that biofuels production in general consumes several orders of magnitude more water than electrolytic hydrogen production, or electricity generation from solar thermal power plants (Table 1). Sea water desalination for electrolytic hydrogen production requires 0.13%-0.16% of the power consumption required for the electrolysis process itself (Lutfi & Veziroğlu, 1991), (Hydrogenics, 2006).

Area	Theme	Subject
1. Environmental	1.1 Climate	1.1.1 GHG balance 1.1.2 Carbon sinks
	1.2 Biodiversity	1.2.1 Biodiversity
	1.3 Local environmental effects	1.3.1 Air quality 1.3.2 Soil quality, erosion 1.3.3 Water quality and resources management
2. Social	2.1 Social well-being	2.1.1 Social well-being of employees and local population
		2.1.2 Health and safety
		2.1.3 Pay and conditions for employees, trade unions
		2.1.4 No child employment
		2.1.5 No discrimination
		2.1.6 Women's rights
3. Economic	3.1 Local economic effects	3.1.1 Local prosperity
	3.2 Economic sustainability	3.2.1 Long-term economic and financial viability
4. Other	4.1 Competition with food/ other indirect effects of land use change	4.1.1 Food competition
		4.2.1 Transparency, stakeholder participation
	4.2 Governance	4.2.2 Compliance with applicable laws, regulations and customary rights
		4.2.3 Land use rights
		4.2.4 Documentation, implementation, monitoring
		4.2.5 Training
	4.3 Good Agricultural Practice	4.2.6 Environmental and Social Impact Assessment for Planning and Implementation
		4.2.7 Continuous improvement in social and environmental aspects
		4.2.8 Criteria conformance and corrective action
	4.4 Biotechnology	4.3.1 Minimum level of maintenance
4.3.2 Integrated pest management		
Certification Procedures	Supply Chain Options	Chain of Custody (segregation, mass balance), Book & Claim
	Geographic Scope	
	Sectoral	

Fig. 1: LBST nomenclature for sustainability criteria

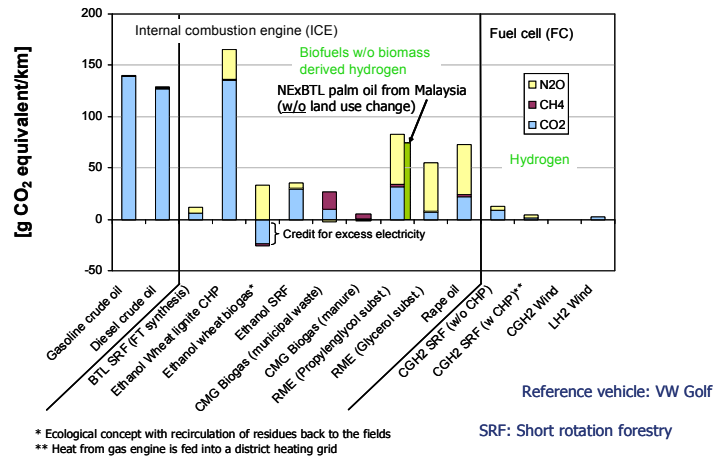


Fig. 2: GHG emissions “well-to-wheel” excluding land use change emissions (palm oil emissions are up to 25 times diesel emissions if land use change is considered)

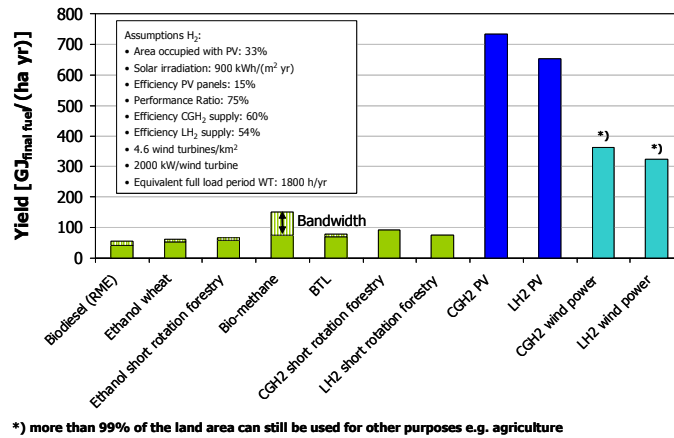


Fig. 3: Yield of biofuels compared to hydrogen produced from wind power or PV

Use of one hectare of land for fuel production...

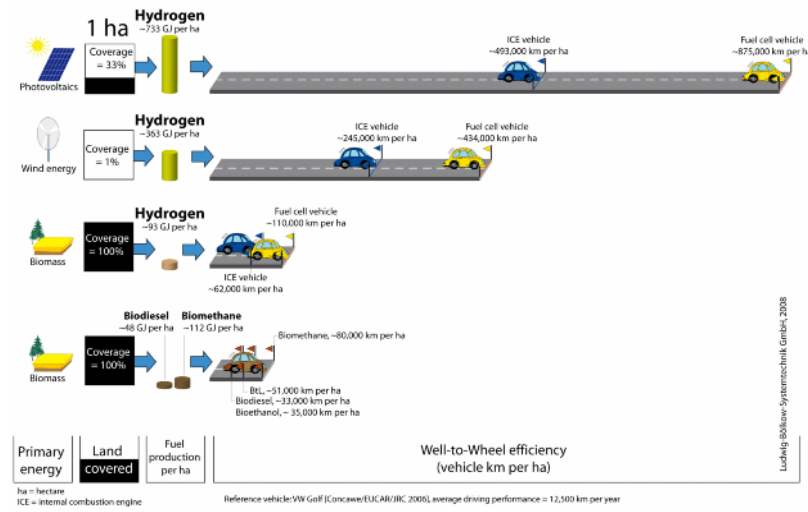


Fig. 4: Driving distance with the fuel yield from one hectare of land

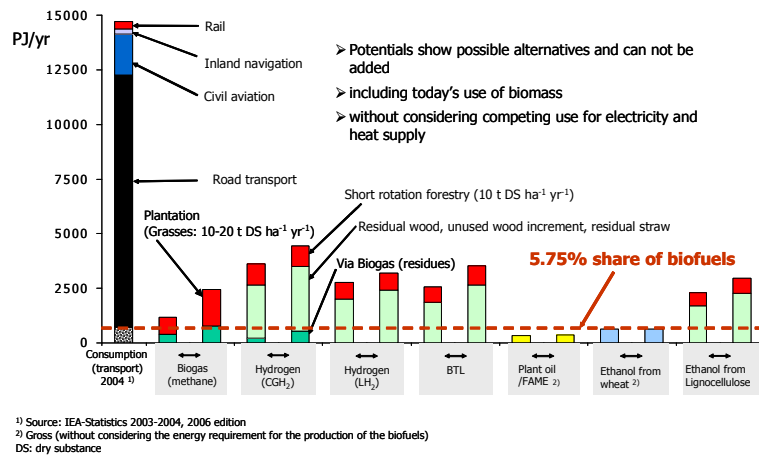


Fig. 5: EU-27 technical potential for biomass derived fuels (VES, 2007)

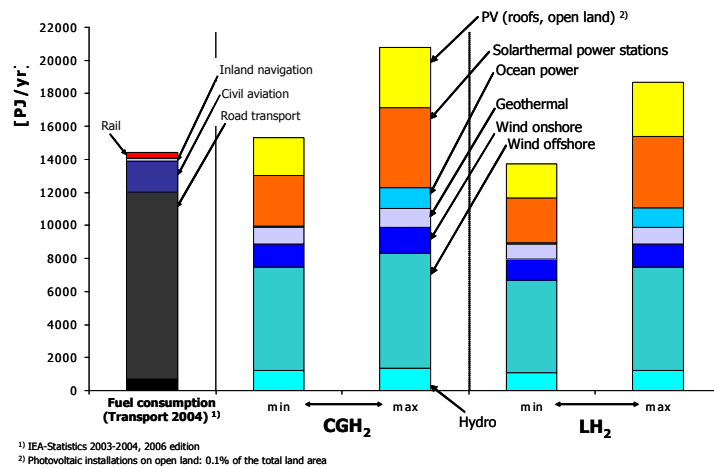


Fig. 6: EU-27 technical potential for hydrogen from renewable electricity (VES, 2007)

Table 1: Water requirement for the cultivation of various crops used for biofuels, for electrolytic hydrogen production and for renewable electricity generation

Crop	Region	Water requirement [kg/kg _{crop}]	Final fuel	Water requirement [kg/MJ _{final fuel}]
Corn	USA	1400	Ethanol	157
Soybean	USA	2000	FAME	291
Sugar cane	e.g. Brazil	1500-3000	Ethanol	772-1544
Wheat	e.g. EU	900	Ethanol	115
Jatropha	India	625-1875	FAME	47-140
Hydrogen from PV	Pakistan	–	Hydrogen	0.75
PV or wind power	Worldwide	–	Electricity	0
Solar thermal power plant	Morocco	–	Electricity	0.28-1.25 ¹⁾

¹⁾ lower, upper value assuming dry cooling, wet cooling, respectively (Altmann, 1994)

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BRIEF BIOGRAPHY OF PRESENTER

Christoph Stiller holds a Degree in Mechanical Engineering from Munich University of Technology and a PhD from the Norwegian University of Science and Technology. Since 2001 he is with Germany-based Ludwig-Bölkow-Systemtechnik (LBST), a strategy and technology consultants for sustainable energy and transport systems working on sustainability issues for more than 25 years.