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Session “Hydrogen Energy: A Vision For the Future”

GREEN FUELS

SUSTAINABILITY CRITERIA APPLIED TO HYDROGEN, BIOFUELS AND ELECTRICITY FOR TRANSPORTATION

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Profile of Ludwig-Bölkow-Systemtechnik

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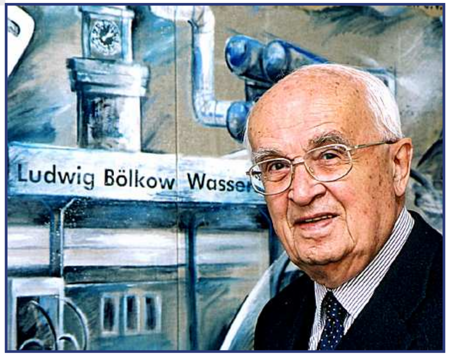
Strategy and technology consultants for sustainable energy and transport systems



Dr. Ludwig Bölkow, † 2003
Founder of LBST and MBB (today EADS)

- Founded in 1982
  25 years of experience in sustainability issues
  20 years with fuel cells, hydrogen and infrastructure
  10 years with fossil resource analyses
- Global, long term and system perspective
- Focus on technologies for sustainability
- Clients from industry, politics and NGOs worldwide
- Interdisciplinary team with high continuity
- Shareholders: TÜV SÜD (47%), LBST staff (29%), Ludwig Bölkow Foundation (12%), Private person (12%)

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Sustainability Criteria

LBST nomenclature

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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 Governance	4.2.1 Transparency, stakeholder participation
		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
		4.2.6 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
	4.3 Good Agricultural Practice	4.3.1 Minimum level of maintenance
		4.3.2 Integrated pest management
		4.3.3 Use of agrochemicals
		4.3.4 Waste reduction, recycling, re-use, disposal
	4.4 Biotechnology	4.4.1 Genetically modified organisms
Certification Procedures	Supply Chain Options	Chain of Custody (segregation, mass balance), Book & Claim
Scope	Geographic	
	Sectoral	

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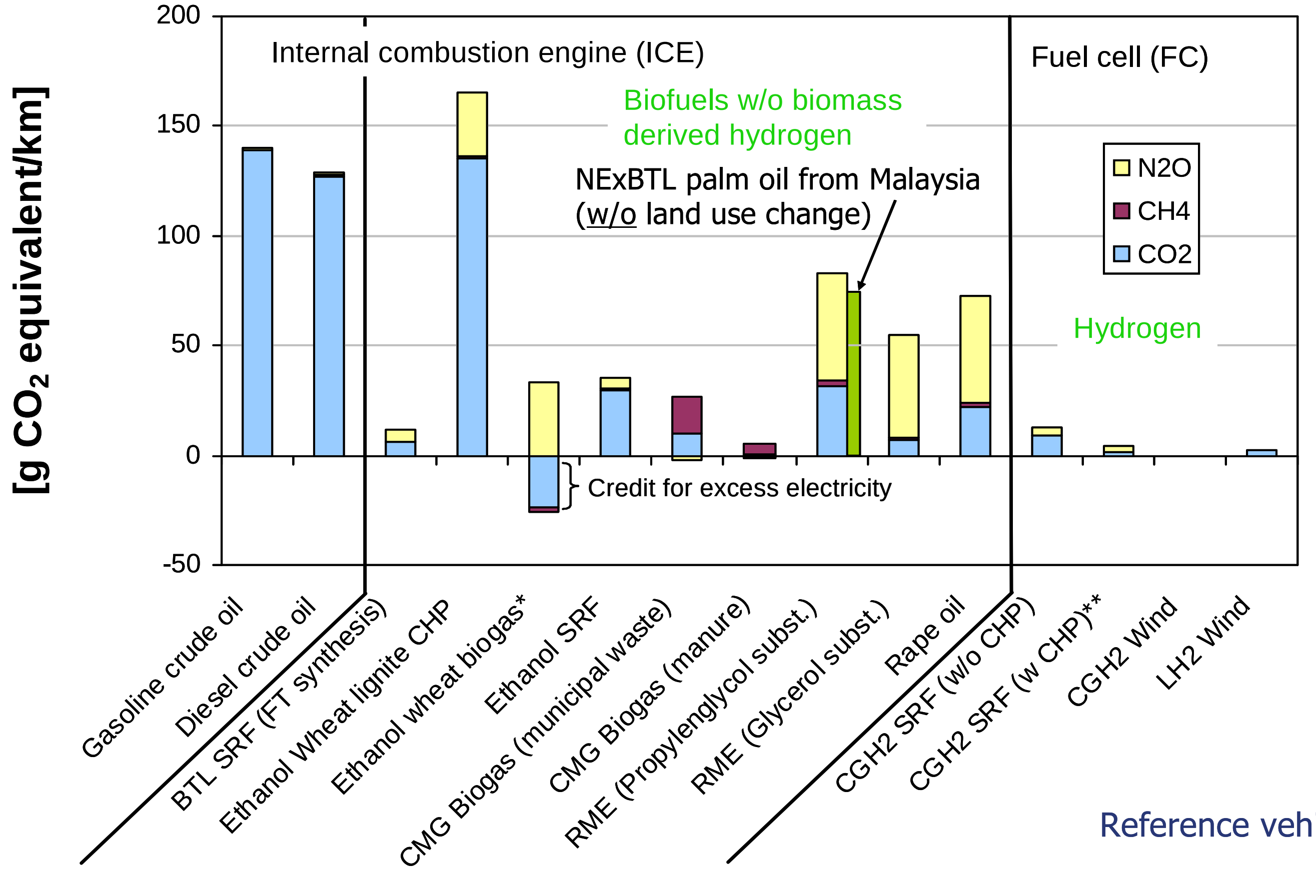
Greenhouse gas emissions (GHG)

- Large bandwidths, especially with biofuels
- 100% reduction with renewable power and selected biofuel pathways
- Certain biomass pathways result in significant increases in GHG emissions



Sources:
JEC 2007
LBST E3database

Reference vehicle: VW Golf

SRF: Short rotation forestry

* Ecological concept with recirculation of residues back to the fields
** Heat from gas engine is fed into a district heating grid

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GHG emissions from oil palm plantation on peatlands in Indonesia

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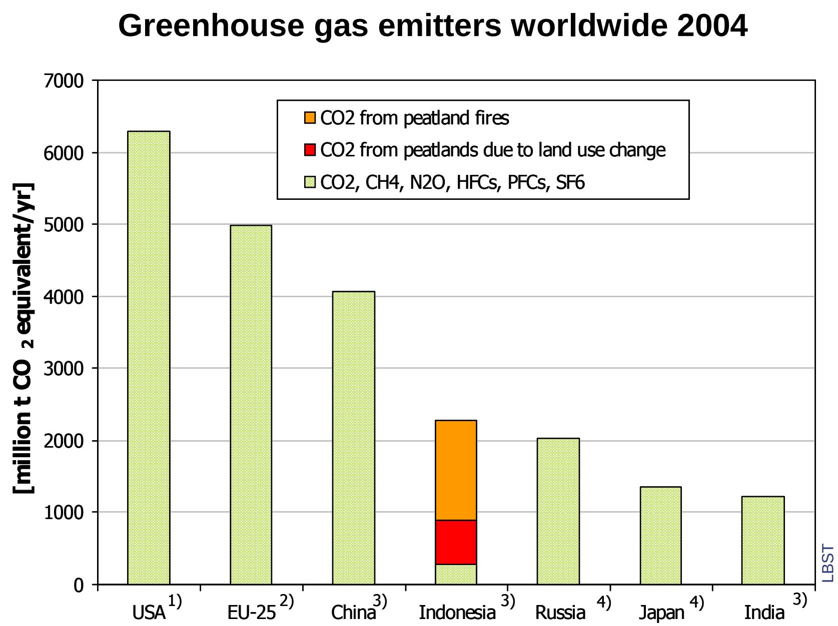
- 70 to 100 t CO_2 per ha and year are emitted due to the decomposition of soil carbon [1].
- Palm oil yields in Indonesia are about 4.1 t per ha and year [2]. The lower heating value (LHV) of palm oil is about 37 GJ/t.
- Considering the decomposition of soil carbon only, this results in CO_2 emissions of **5 to 8 times** of those for the supply and use of conventional diesel.
- Including peatland fires, CO_2 emissions are up to **25 times** of those for the supply and use of conventional diesel [3].
- This made Indonesia the fourth largest emitter of greenhouse gases in 2004 (see chart).

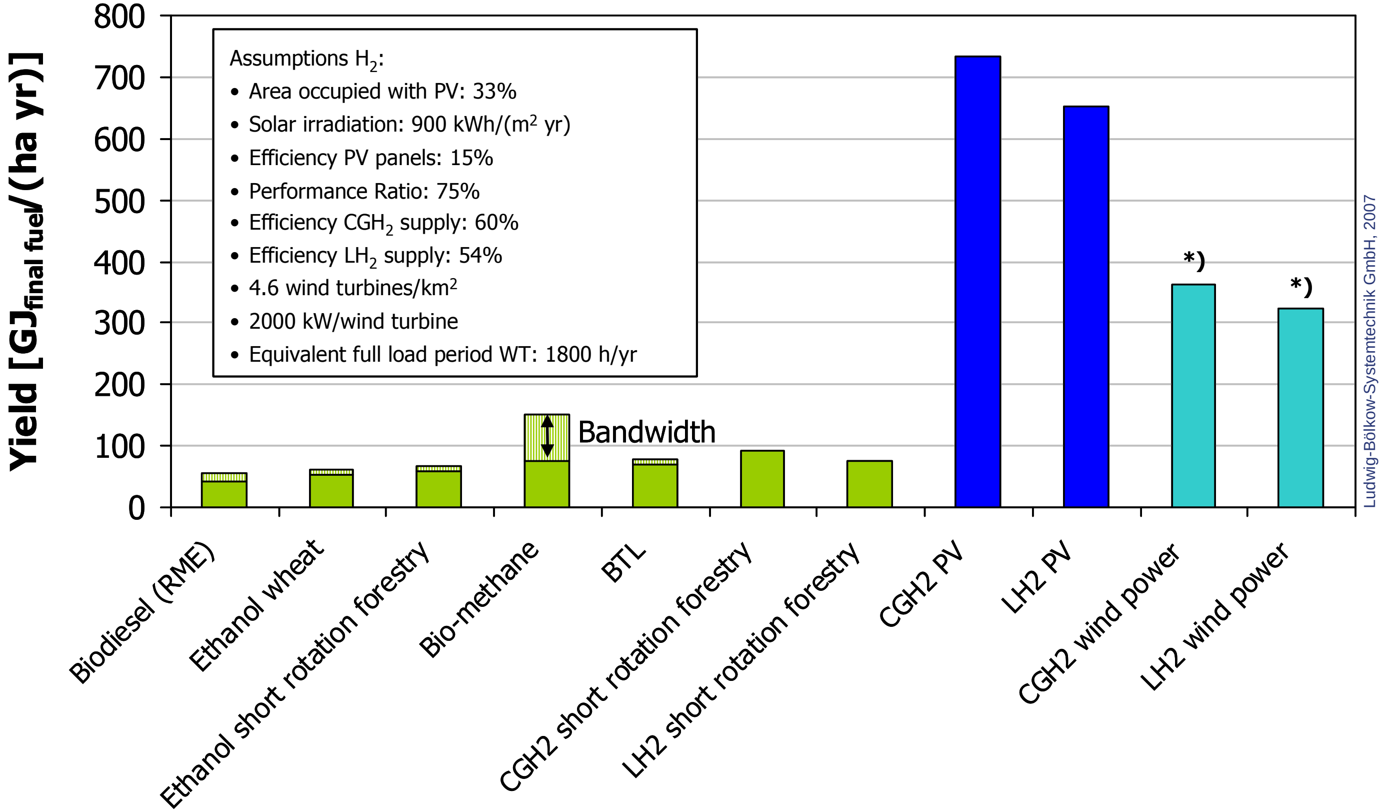


Sources:
1) U.S. Environment Protection Agency (EPA), April 2006
2) European Environmental Agency (EEA), 2007
3) www.wetlands.org, November 2006
4) UNFCCC, 2006

[1] Hooijer, A., Silvius, M., Wösten, H. and Page, S. (2006): PEAT-CO2, Assessment of CO2 emissions from drained peatlands in SE Asia. Delft Hydraulics report Q3943, 2006; www.wetlands.org
[2] Yield in Indonesia according to FAO (2006): 18,5 t Fresh Fruit Bunches (FFB) per ha and year; 225 kg_{oil}/t_{FFB}
[3] Siegert, F., cited in: Süddeutsche Zeitung, 11 April 2007

Land Use

- Yield of biofuels versus hydrogen from wind power or PV

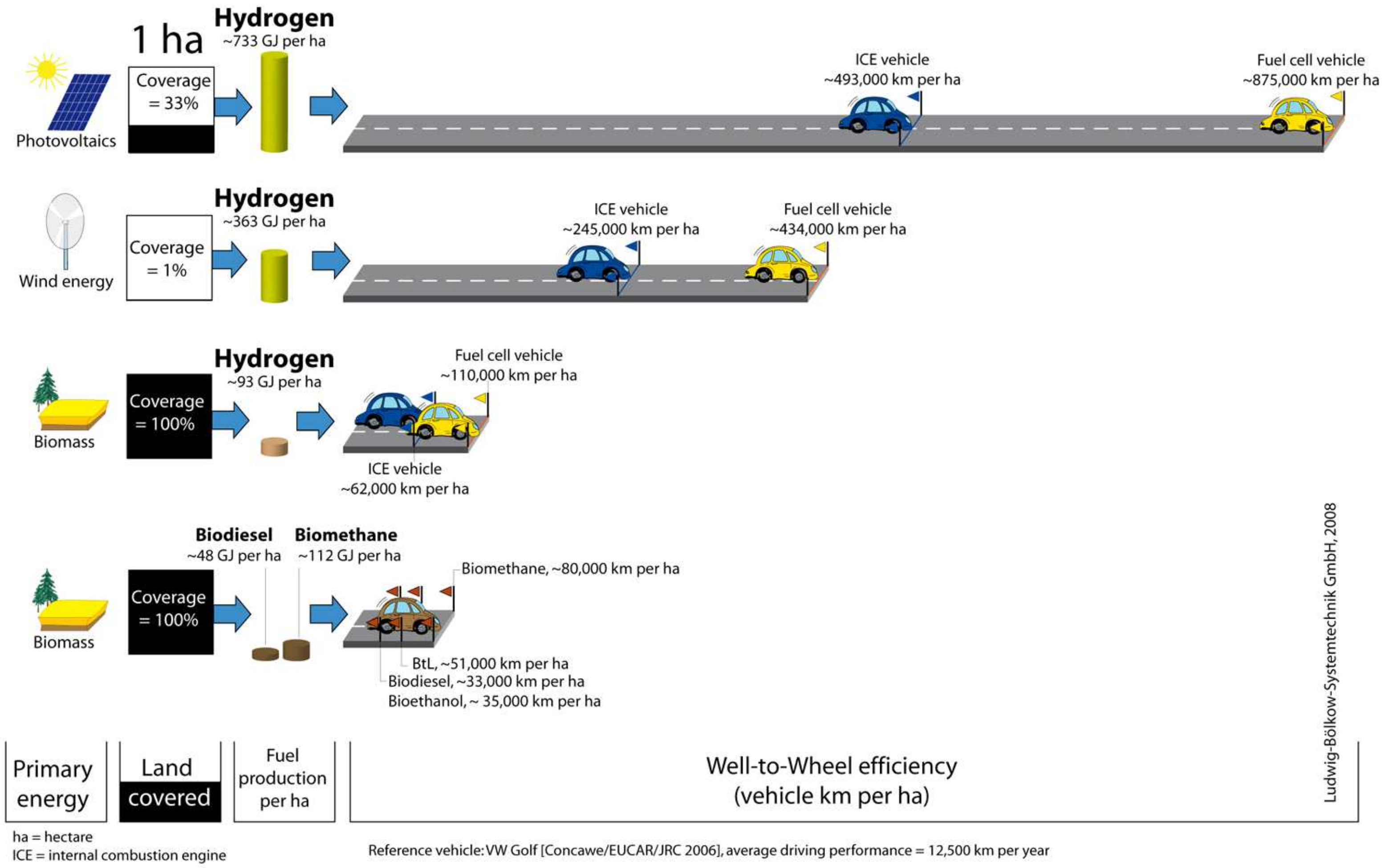


***) more than 99% of the land area can still be used for other purposes e.g. agriculture**

Source: Weindorf & Altmann, 2007

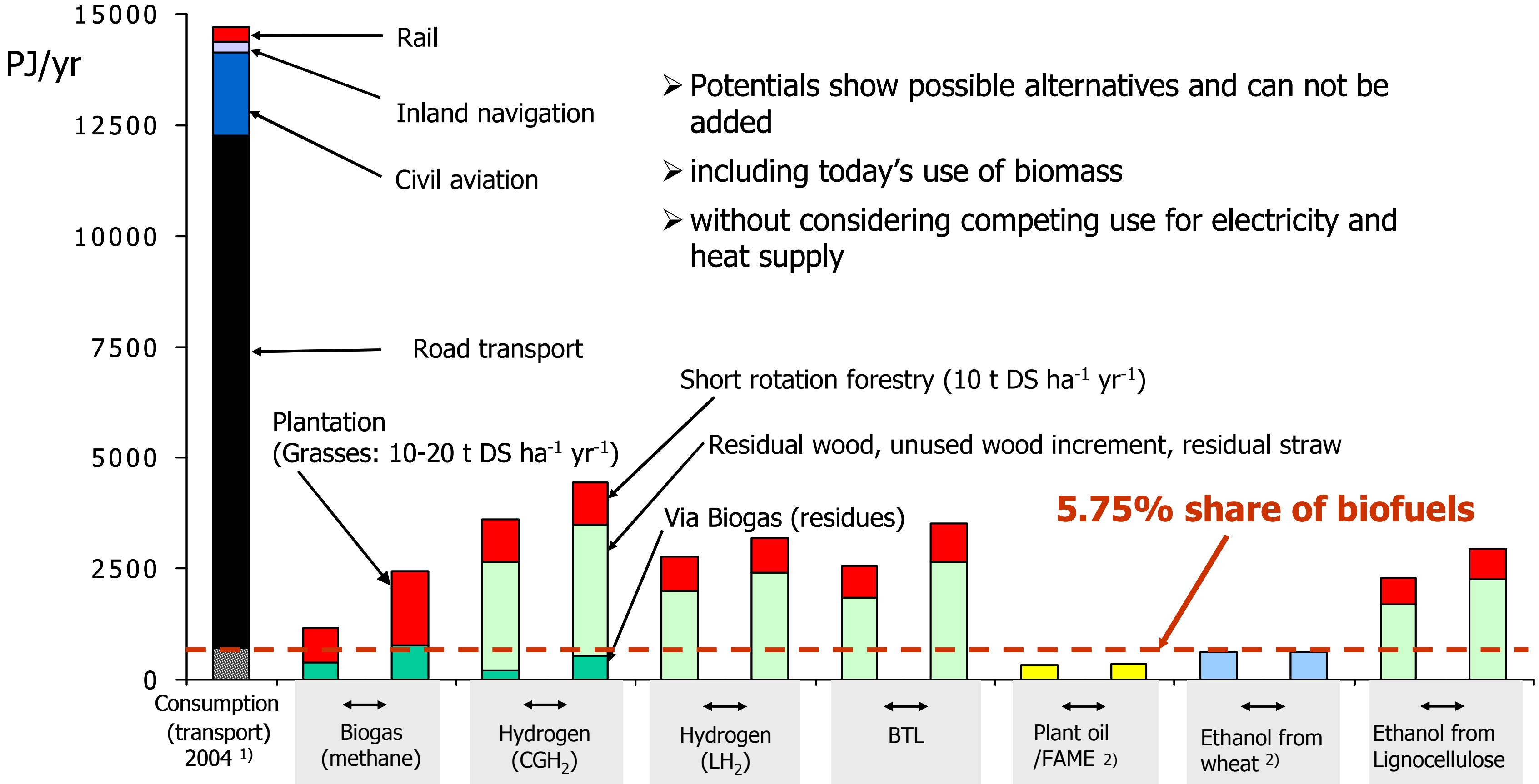
Land Use

- Driving distance with the fuel yield from one hectare of land



Source: LBST for EHA/DWV, Hydrogen & Renewables, 2008

Biofuel Potentials in the EU-27

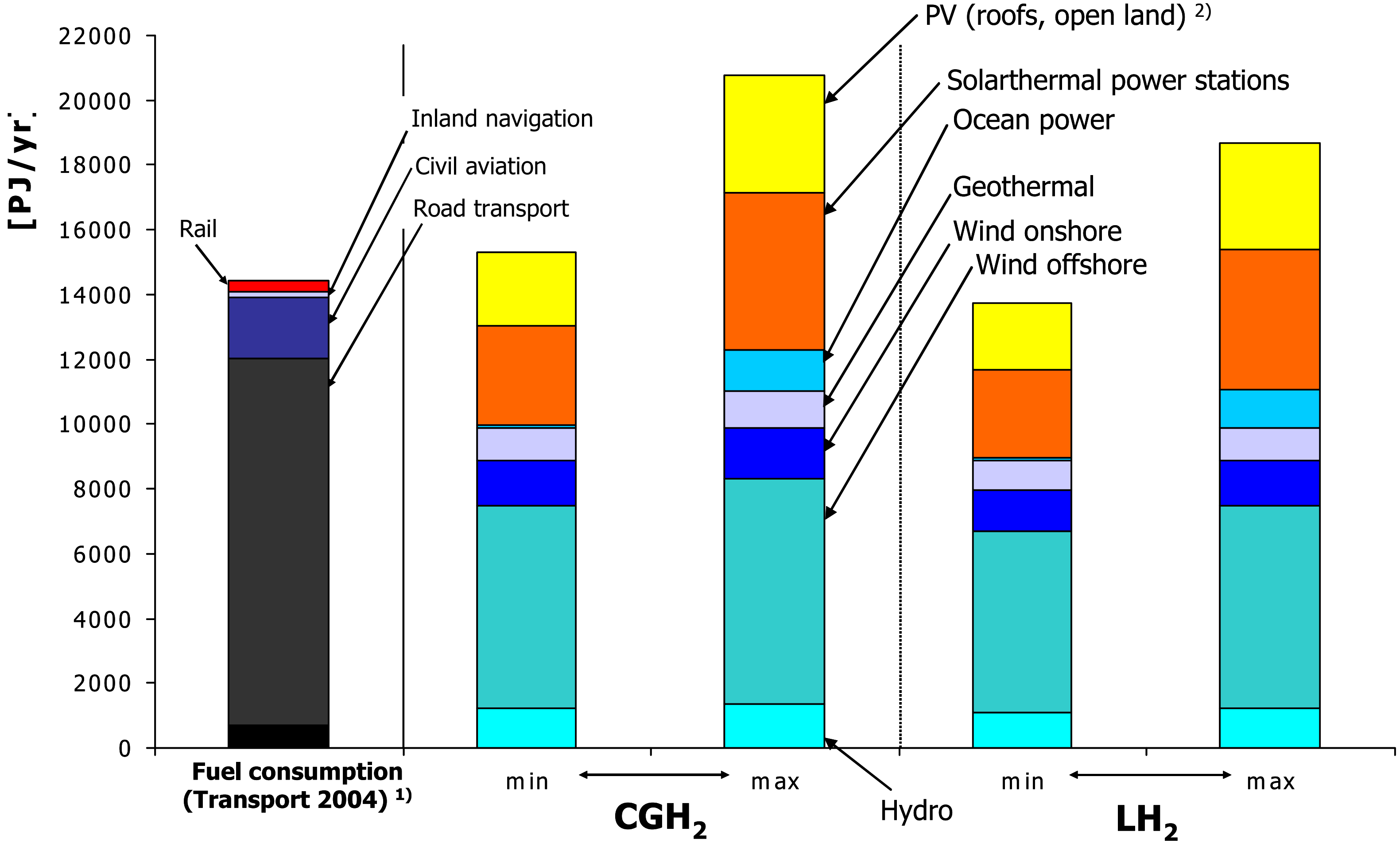


- Potentials show possible alternatives and can not be added
- including today's use of biomass
- without considering competing use for electricity and heat supply

[1] Source: IEA-Statistics 2003-2004, 2006 edition
[2] Gross (without considering the energy requirement for the production of the biofuels)
DS: dry substance

Source: VES, 2007

Electricity Potentials in the EU-27



1) IEA-Statistics 2003-2004, 2006 edition

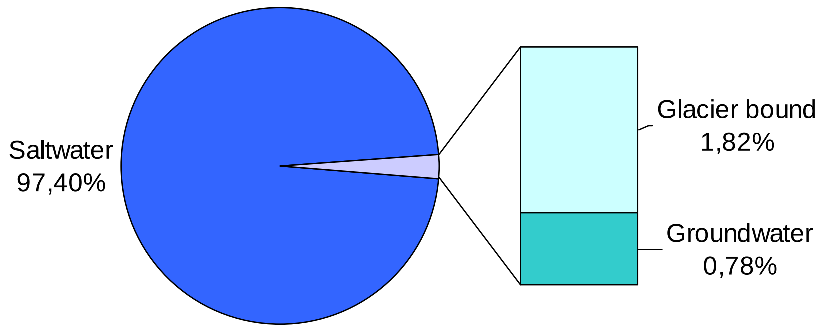
2) Photovoltaic installations on open land: 0.1% of the total land area

Source: VES, 2007

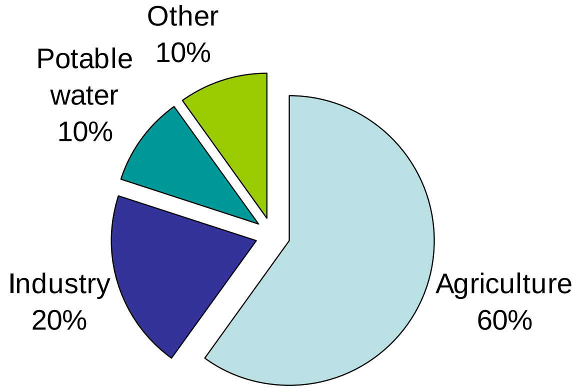
World Water Demand and Sources

- World water consumption has increased 100 times over the last 100 years
- Currently, some 5,500 km³ are consumed every year
- Thereof, some 3,300 km³ are taken from various reservoirs
- Less than 50% of water consumption stems from natural rainfall
- In many regions of the world groundwater levels are rapidly decreasing:
  - In some regions of the USA by more than 60 m
  - In Luancheng province (China's bread-basket) by about 20 m since 1974
  - In India's Gujarat province water levels fell from 10 to 400 m during the last 50 years
  - In Jemen it's decreasing by 10 m annually
- Intensive farming leads to contamination of ground and surface water with pesticides and nitrates

Water Sources



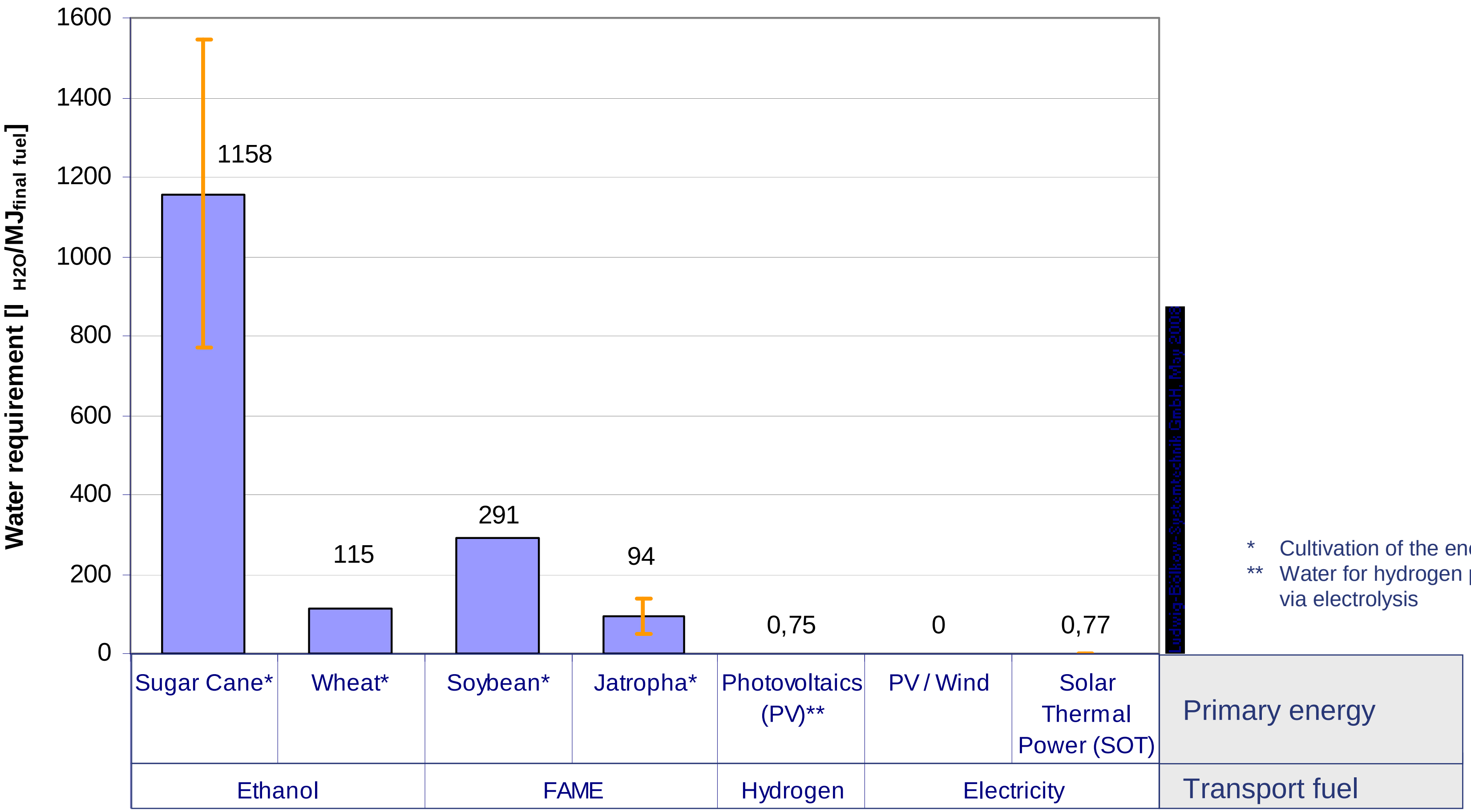
Water Consumption by Sector



Sources: LBST; VDI-Nachrichten, 2 May 2008; Andrea Naica-Loebell, 25 March 2006

Water Intensity of Transportation Fuels

- Net water requirements for crop cultivation is subject to local climatic conditions
- In general, biofuels consume several orders of magnitude more water than electrolytic hydrogen production



* Cultivation of the energy crops
** Water for hydrogen production via electrolysis

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Water Intensity of Transportation Fuels

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Primary energy	Region	Water requirement [l/kg_{crop}]	Final fuel	Water requirement [$l/MJ_{final\ fuel}$]
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*
Photovoltaic (PV)	Pakistan	–	Hydrogen	0.75 **
PV or wind power	Worldwide	–	Electricity	0
Solar thermal power plant (SOT)	Morocco	–	Electricity	0.28-1.25 ***

* Cultivation of the energy crops
** Water for hydrogen production via electrolysis
*** Lower and upper values assuming dry cooling and wet cooling, respectively

Sources: Altmann, 1994
Lutfi & Veziroğlu, 1991
Hydrogenics, 2006

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Summary and Conclusions

- **Greenhouse gas emissions** attributed to biofuels, hydrogen and electricity vary between zero and several times that of conventional fuels
- Hydrogen and renewable electricity perform significantly superior to any of the biofuel production pathways with respect to **land-use**
- Strong **competition** between land for the production of biomass for food, feed, heating and construction material
- Biofuels' **water** requirements provide for a broad bandwidth with strong sensitivities regarding local climatic conditions
- Analyses based on average or typical values show that biofuels production in general consumes several orders of magnitude more **water** than hydrogen production from photovoltaics, wind or solar thermal power plants
- Comprehensive **life-cycle analyses** are required for assessing the sustainability of alternative transportation fuels with biofuels being the most complex case
- 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 quantitatively and qualitatively if based on renewable energies

LBST hydrogen and fuel cell information online

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H2stations.org

All hydrogen filling stations worldwide

H2mobility.org

All hydrogen cars, buses, trucks, ships, aviation, and speciality vehicles

HyWeb.de

News bits, calendar of events

LBST.de

Projects, reports, presentations

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Thank you!

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