

EVS24 · Stavanger · Norway · 13-16 May 2009

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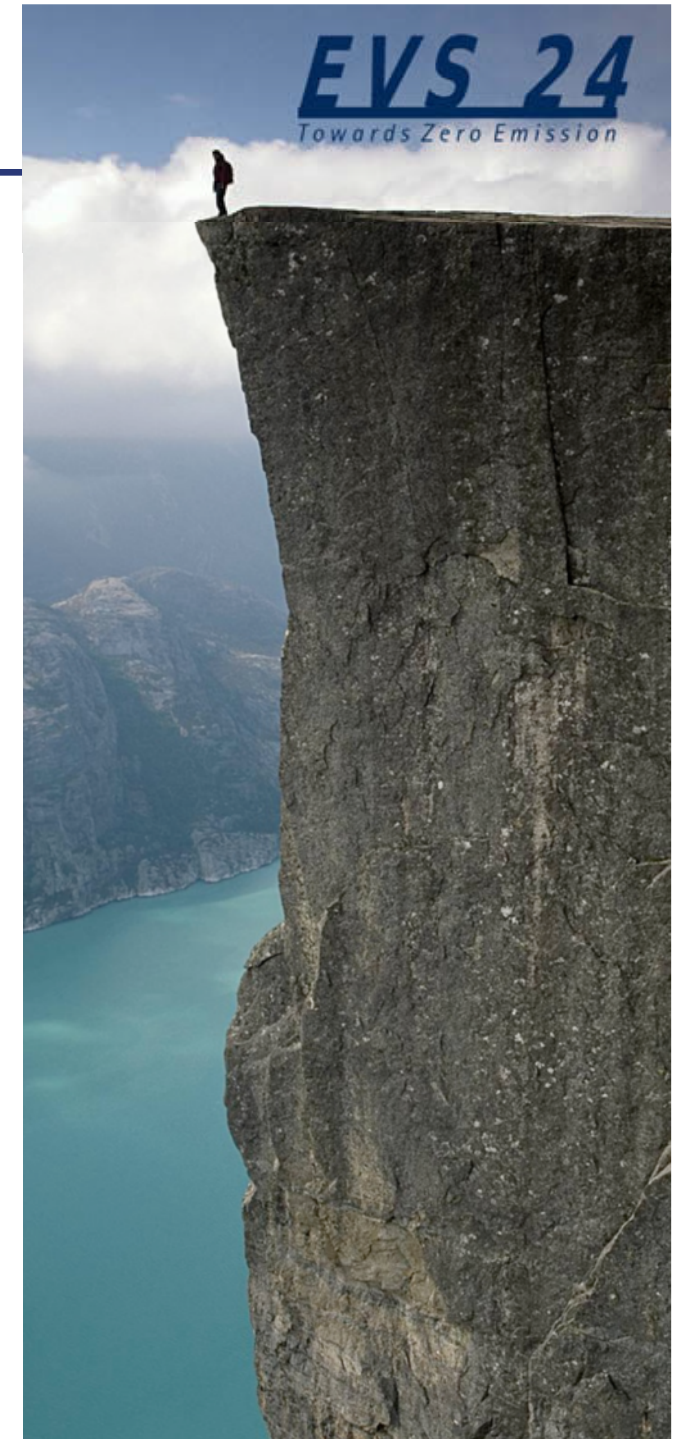
Session “Environmental Impacts & Life Cycle Analysis”

## Sustainability of Transport Fuels

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1. LBST Profile
2. EU Renewables Directive
3. Selected Sustainability Criteria
4. Summary and Conclusions

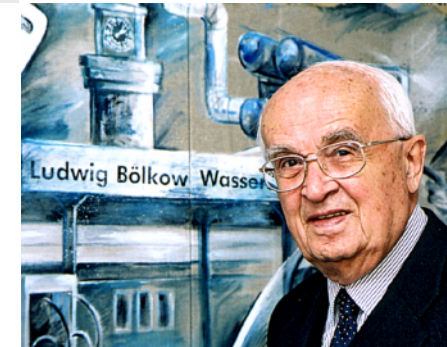


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## Strategy and technology consultants for sustainable energy and transport systems

- ▶ 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%)



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



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- **Mandatory target for renewable transport fuels** of 10% by 2020 for each EU Member State.
- **Biofuels, electricity and hydrogen** are explicitly mentioned as contributors to the renewables in transport target:
  - **Electricity:** Share of renewables in the grid mix is to be assumed
  - **Hydrogen:** Calculation method yet to be defined
  - **Biofuels:** Comprehensive list of sustainability criteria
- Compliance with **sustainability criteria** required as laid out in the **EU Renewables Directive** (EU RE-D).
- Two **types** of sustainability criteria:
  - legally binding thresholds on environmental issues (GHG, land-use change)
  - reporting obligations on environmental, social and economic issues
- **Non-compliant** renewable fuels may still be sold in the EU, but selling on a compliance basis will likely achieve a premium price.



*“EU Directive on the promotion of the use of energy from renewable sources”*

- **Stage reached:**
  - Adopted by the European Parliament on 17 December 2008
  - Final decision by the Council pending
  - To be implemented in national law within 18 months after publication in the official journal
  - Compliance procedures to be agreed throughout 2009
  
- **Key elements** as of 17 December 2008:
  - Article 17: Sustainability criteria for biofuels and other bioliquids
  - Article 18: Verification of compliance with the sustainability criteria for biofuels and other bioliquids
  - Annex V: Calculation method for greenhouse gas emissions

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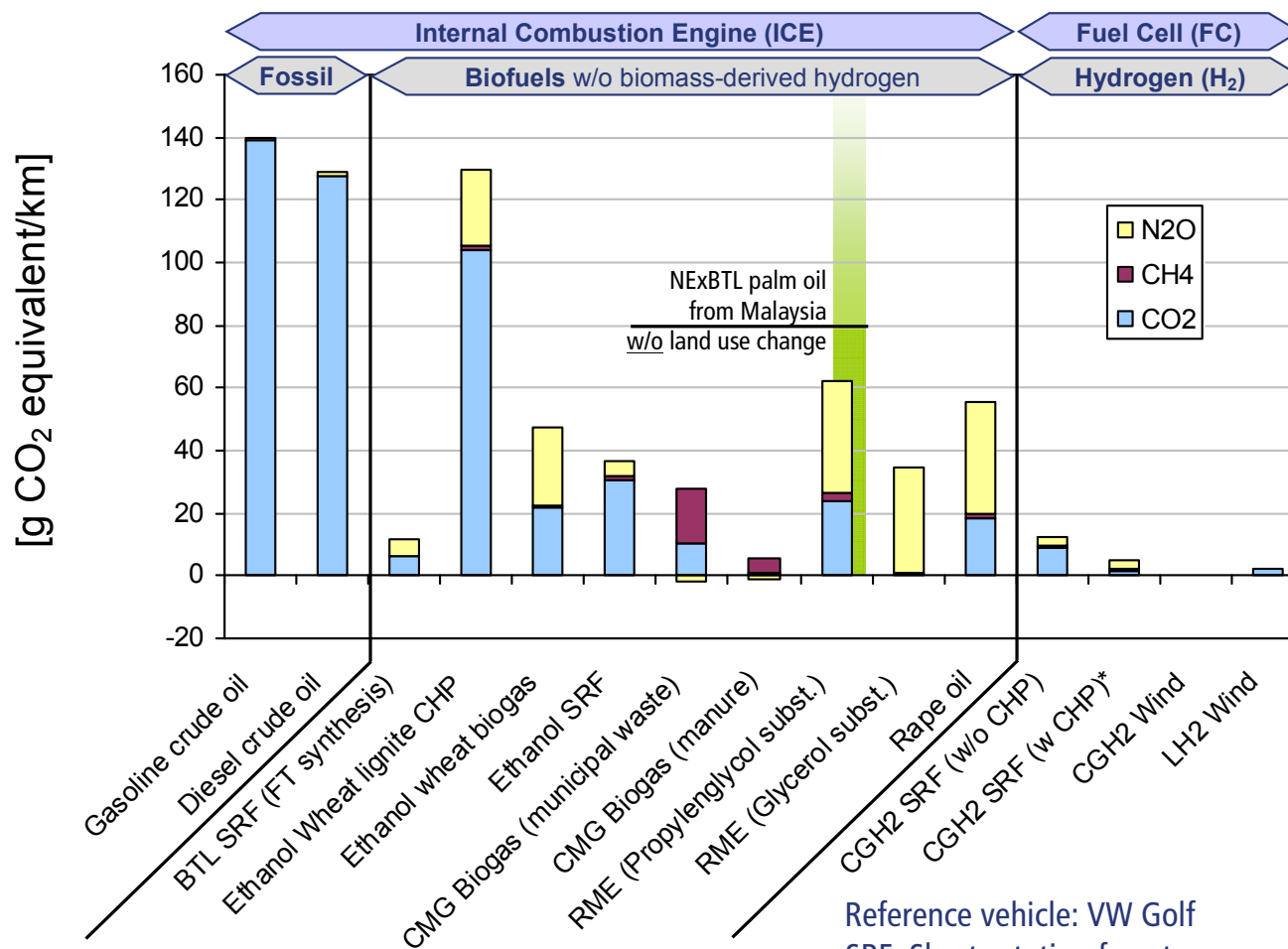


## Greenhouse Gas Emissions



## Greenhouse gas emissions (GHG) without land-use change

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



\* Excess heat from gasifier and gas engine is fed into a district heating grid

Reference vehicle: VW Golf  
SRF: Short rotation forestry  
Sources: JEC 2009, LBST E3database

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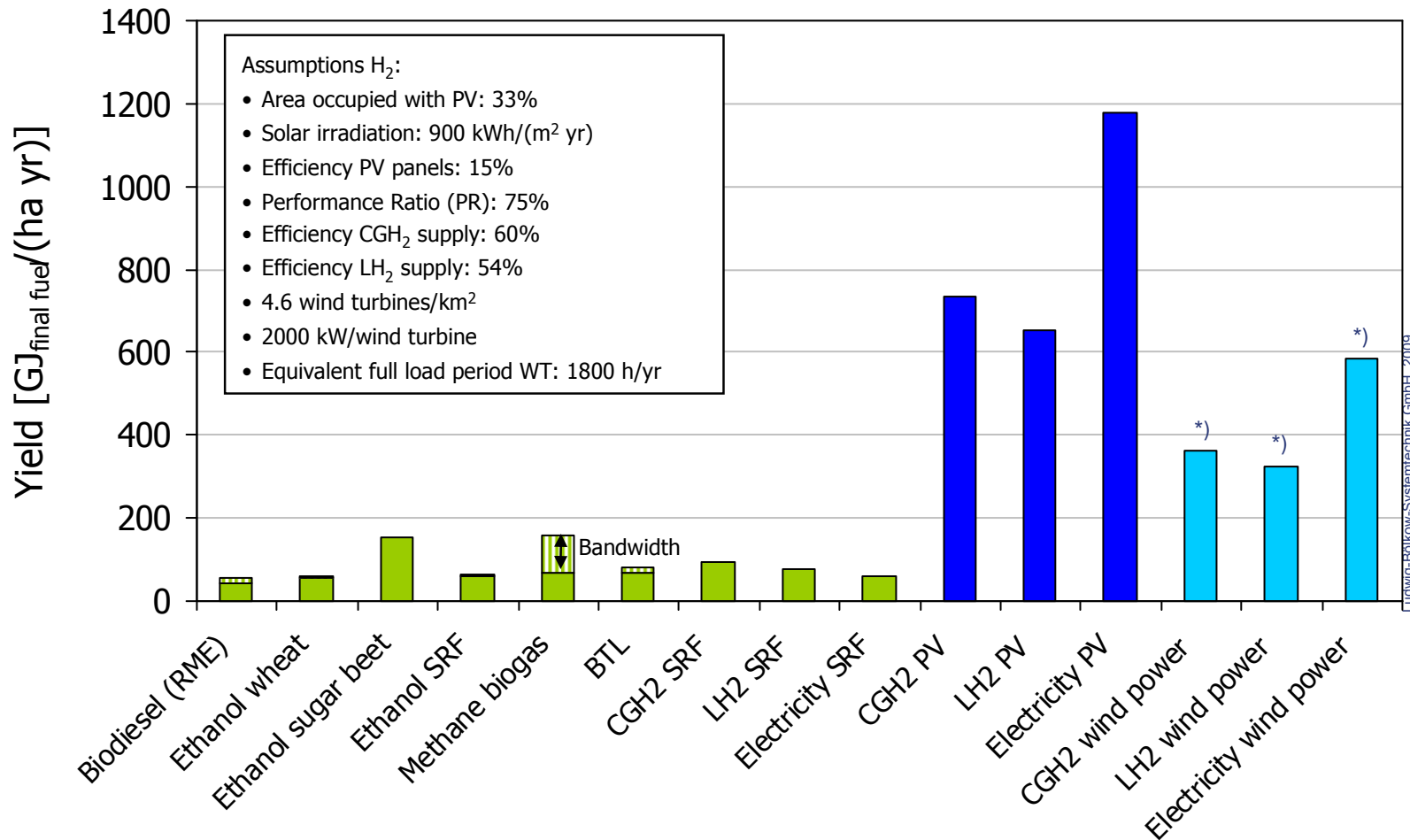
Land

# Land Use



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- Yield of biofuels versus hydrogen and electricity from wind power or PV

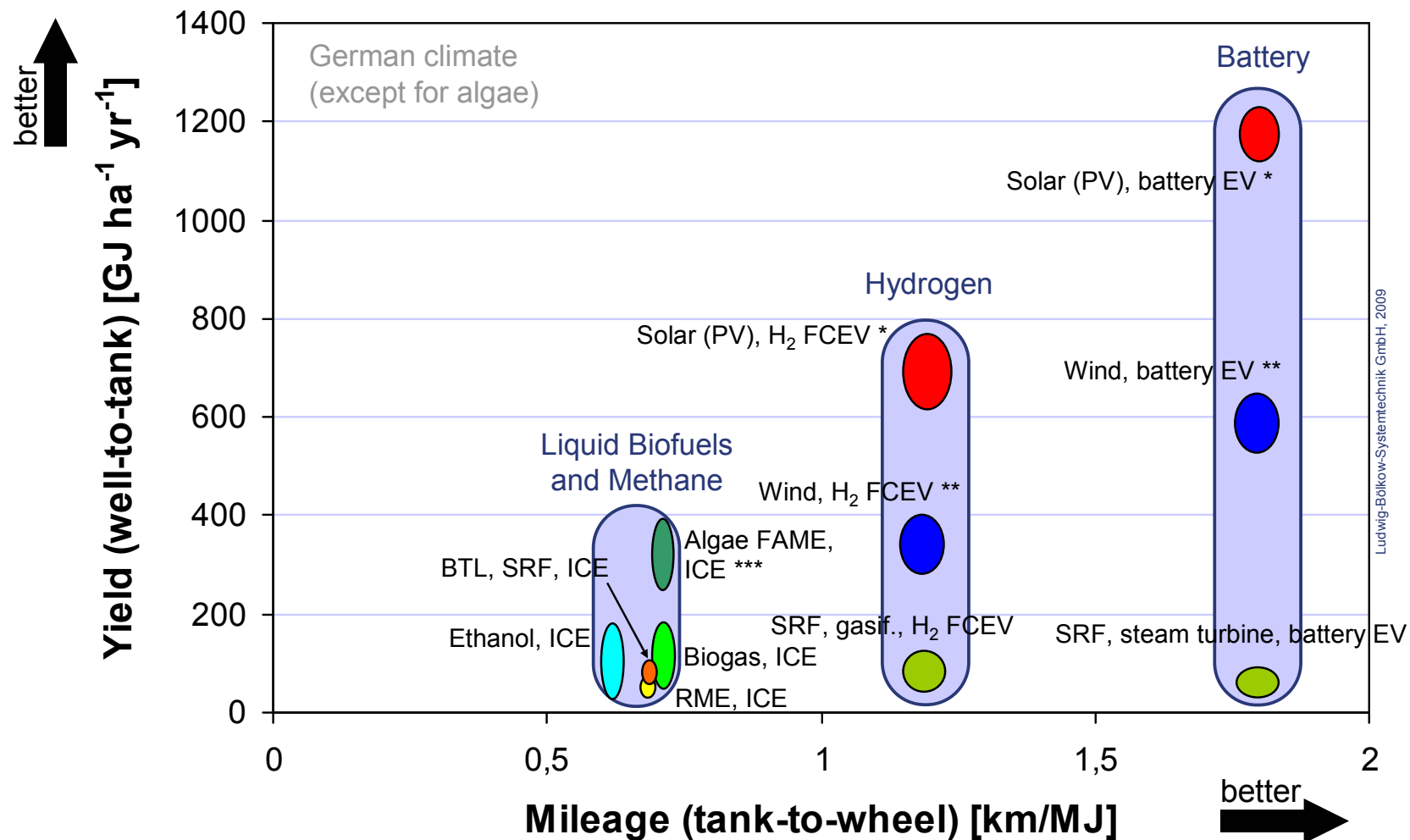


# Performance Mapping of Yield versus Mileage



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- Electric drive trains (H<sub>2</sub> and battery) outperforming biofuels in both dimension



\*) One third of the area is occupied with PV panels

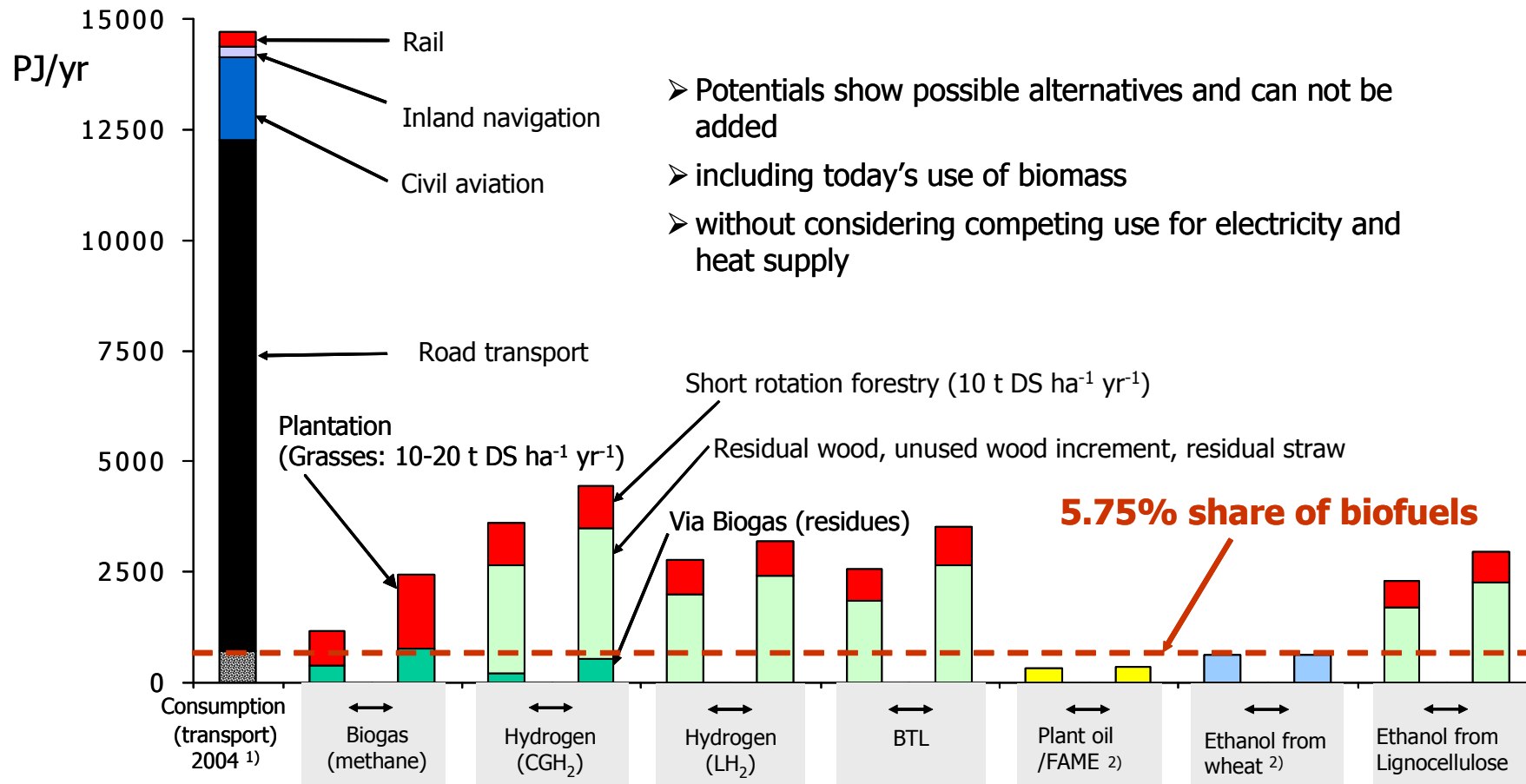
\*\*) more than 99% of the land area can still be used for other purposes e.g. agriculture

\*\*\*) region with high solar irradiation

# Biofuel Potentials in the EU-27



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<sup>1)</sup> Source: IEA-Statistics 2003-2004, 2006 edition

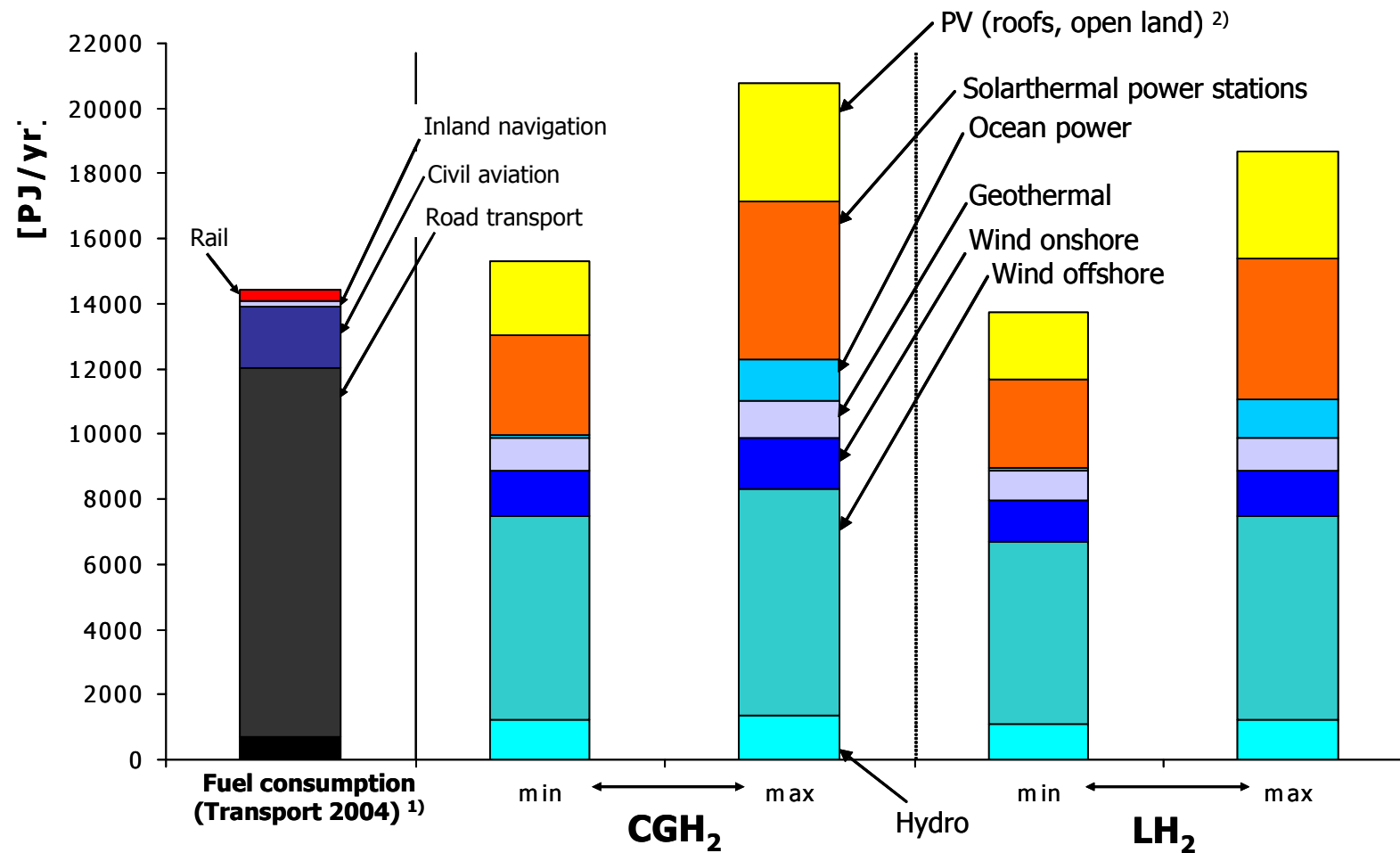
<sup>2)</sup> Gross (without considering the energy requirement for the production of the biofuels)

DS: dry substance

# Electricity Potentials in the EU-27



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<sup>1)</sup> IEA-Statistics 2003-2004, 2006 edition

<sup>2)</sup> Photovoltaic installations on open land: 0.1% of the total land area

Source: VES, 2007

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Water

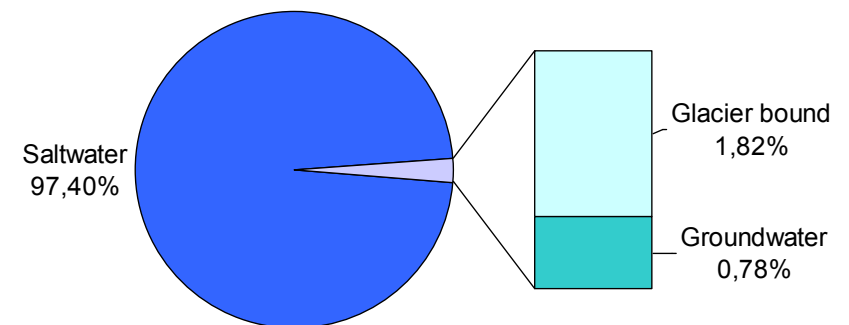
# World Water Demand and Sources



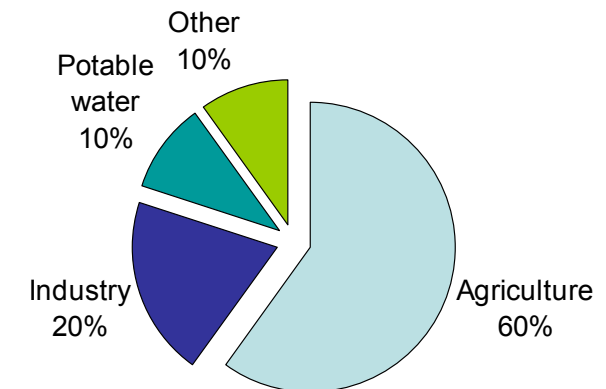
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- World water consumption has increased 100 times over the last 100 years
- Currently, some 5,500 km<sup>3</sup> are consumed every year
- Thereof, some 3,300 km<sup>3</sup> are taken from various reservoirs
- Less than 50% of water consumption stems 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**



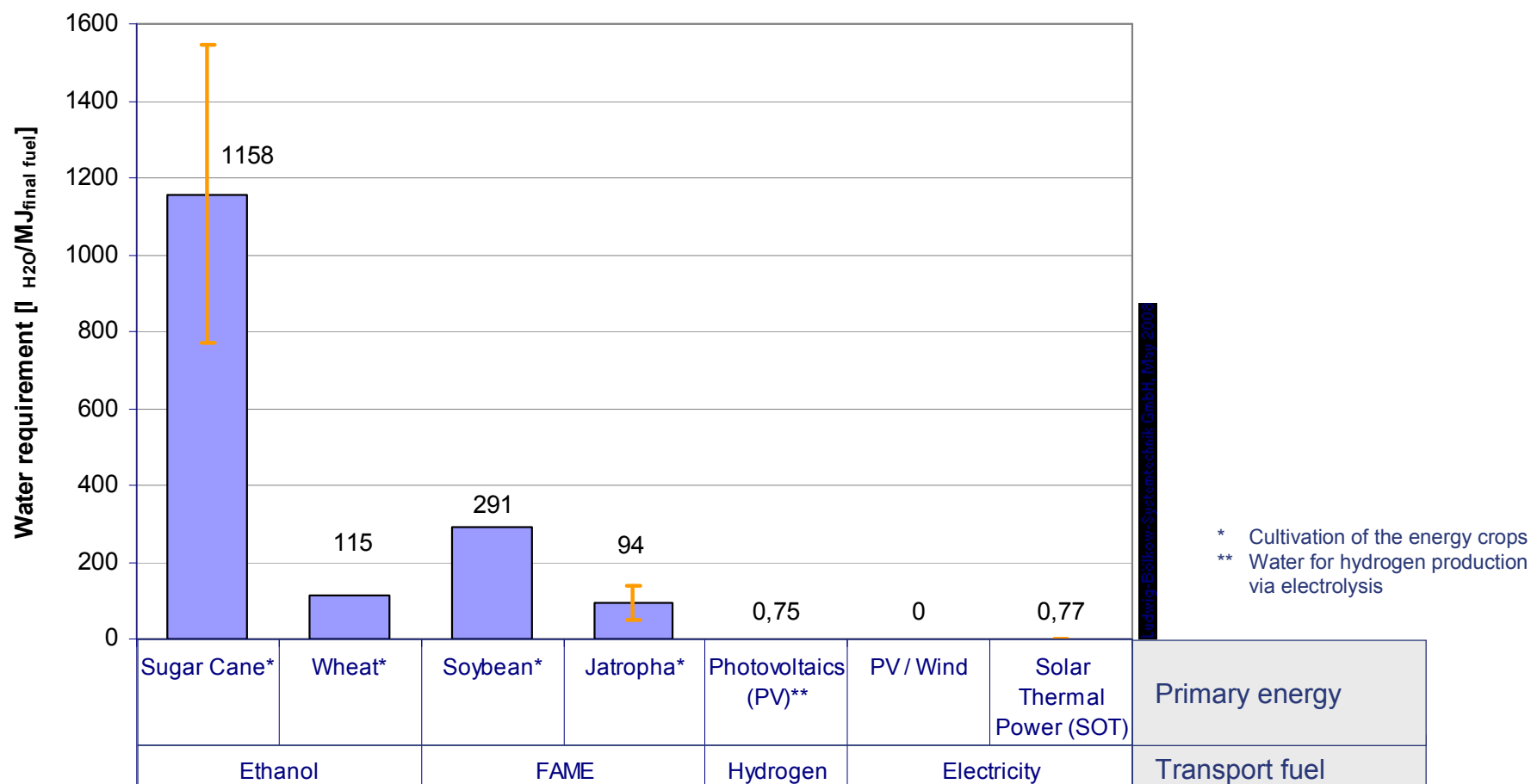
**Water Consumption by Sector**





## 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



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Biodiversity, Social Issue, Local Economy

## Other Sustainability Criteria

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### ■ **Biodiversity**

- Most relevant with biofuels (interaction of ecosystems)
- Major issues are endangered species, invasive species, monoculture, and habitat patterns

### ■ **Social**

- Land ownership
- Labour sourcing, health and safety
- Potentially aggravating inequality through wealth distribution and gender preferences
- Assessment on a single project level insufficient

### ■ **Local Economy**

- Benefits may be great through regular, paid labour (direct and indirect)
- Subsistence economies threatened?
- Vulnerability from market domination
- Assessment on a single project level insufficient

⇒ **Typically, comprehensive analyses are needed for complex criteria like these**

⇒ **'Paternalism' accuse by less developed countries**

⇒ **Social criteria beyond WHO/ILO likely to clash with WTO/GATT**



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## Summary and Conclusions

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- ▶ **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 – It is in general several orders of magnitude higher than for hydrogen 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
- ▶ Benefit of **biofuels** is ambiguous; some may pose serious environmental and social risks
- ▶ There is a hype phenomenon with **algae** – Expectations still need to be confirmed
- ▶ **Electricity and hydrogen** as transport fuels can achieve full sustainability goals quantitatively and qualitatively if based on renewable energies



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# Thank you!



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## Literature

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# Life Cycle Analyses with LBST Cooperation

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**GM WTW Study** – "Well-to-Wheel Analysis of Energy Use and Greenhouse Gas Emissions of Advanced Fuel/Vehicle Systems – A European Study" [2001 - 2002]

**BStMLU Study** – "Comparison of Different Propulsion Systems in Private Transport in Terms of Energy Saving and Reduction of Greenhouse Gases" [2001 - 2002]

**FCSHIP** – "Fuel Cell Technology in Ships" [2002 - 2004]

**HyWays** – European Hydrogen Energy Roadmap Activity [2004 - 2007]

**CONCAWE/EUCAR/JRC** – "Well-to-Wheel Assessment of Alternative Road Transport Fuels – Well-to-Tank" [2002 - 2009]

**Industry** – e.g. "Jatropha Biofuel Sustainability Due Diligence" [2008 - 2009]



# E3 database

## A calculation tool

for the supply and use of energy carriers, products or services:

- Cumulative energy demands
- Material balances, e.g. for the construction of an industrial plant
- Emissions of air pollutants and greenhouse gases (CO<sub>2</sub>, CH<sub>4</sub>, etc.)
- Economic aspects such as investment costs, operation and maintenance costs, depreciation conditions, etc.

