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Session "Systems Analysis and Well-to-Wheel Studies"



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Ludwig-Bölkow-Systemtechnik GmbH (LBST)

Sustainability of Transport Fuels

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1. EU Renewable Energy Directive
2. Energy Potentials
3. Greenhouse Gas & Pollutant Emissions
4. Land-use
5. Water
6. Biodiversity, Social Issue, Local Economy
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EU Renewable Energy Directive



„Promotion of the use of energy from renewable sources” (EU-RED – Directive 2009/28/EC)

- **Mandatory target for renewable transport fuels of 10% by 2020 for each EU Member State.**
- **EU Renewable Energy Directive:**
 - Adopted on 23 April 2009
 - To be transposed into national law by Member States by 5 December 2010
 - Definition of **sustainability goals**
 - legally binding threshold on greenhouse gas emissions
 - go/no-go criteria: land with high biodiversity value, land with high carbon stock
 - reporting obligations on environmental and social issues
 - “All forms of energy” included to make up for 10% target
 - Hydrogen included in Member States’ share of renewable energies
 - Opportunities for renewable hydrogen to be explored



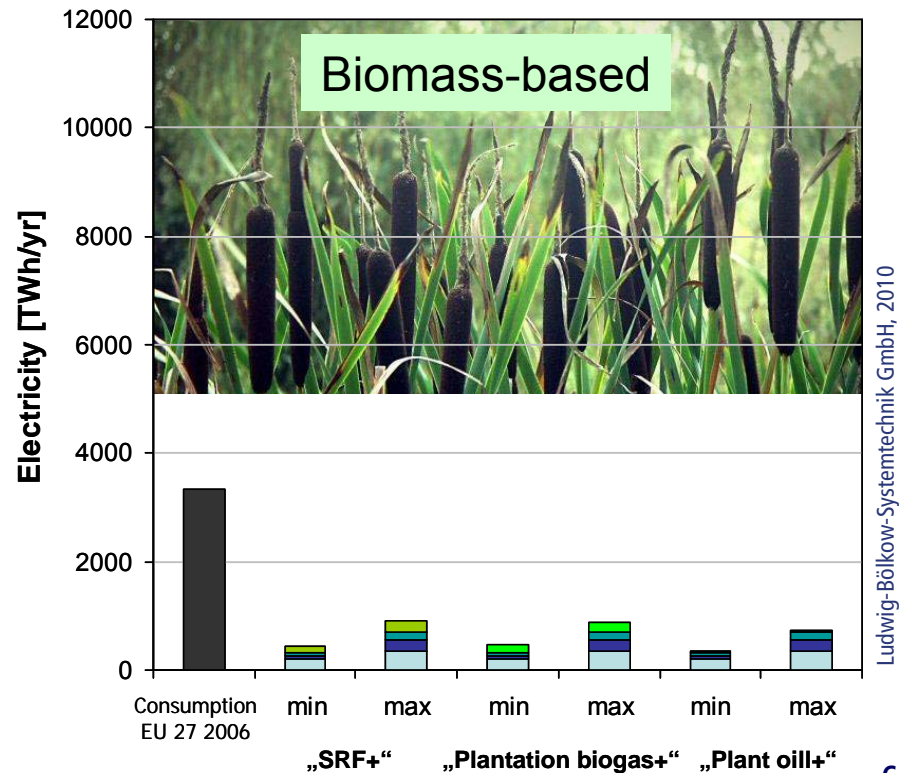
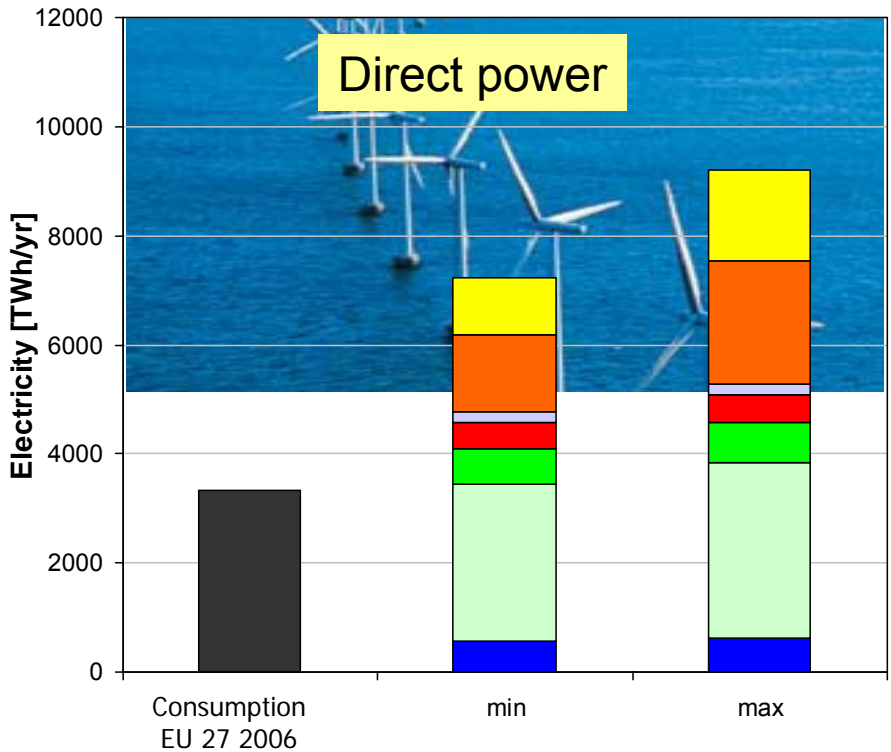
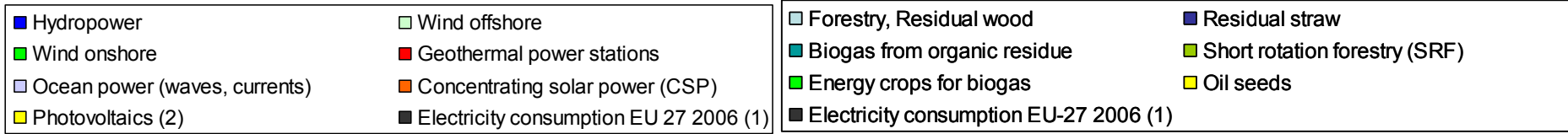
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Energy Potentials

Potential for Renewable Electricity in EU-27



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Ludwig-Bölkow-Systemtechnik GmbH, 2010

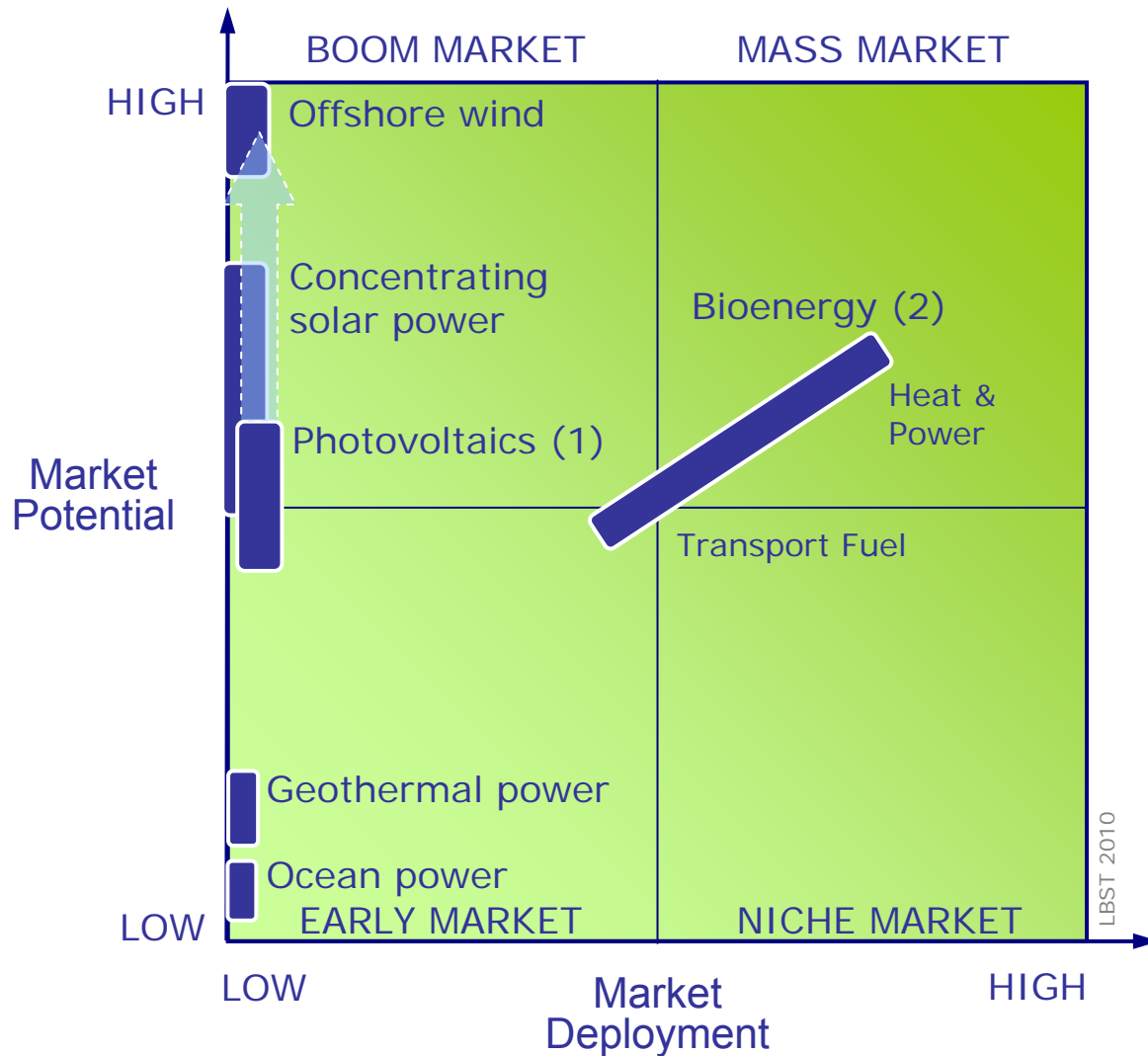
(1) IEA Statistics, 2008
 (2) Roofs (2/3 of the adequate roofs) and open land (0.1% of the total land area)

100% of the biomass potential is used for electricity generation (no biofuels, heat from biomass only via CHP)

Mapping of New Renewable Energies



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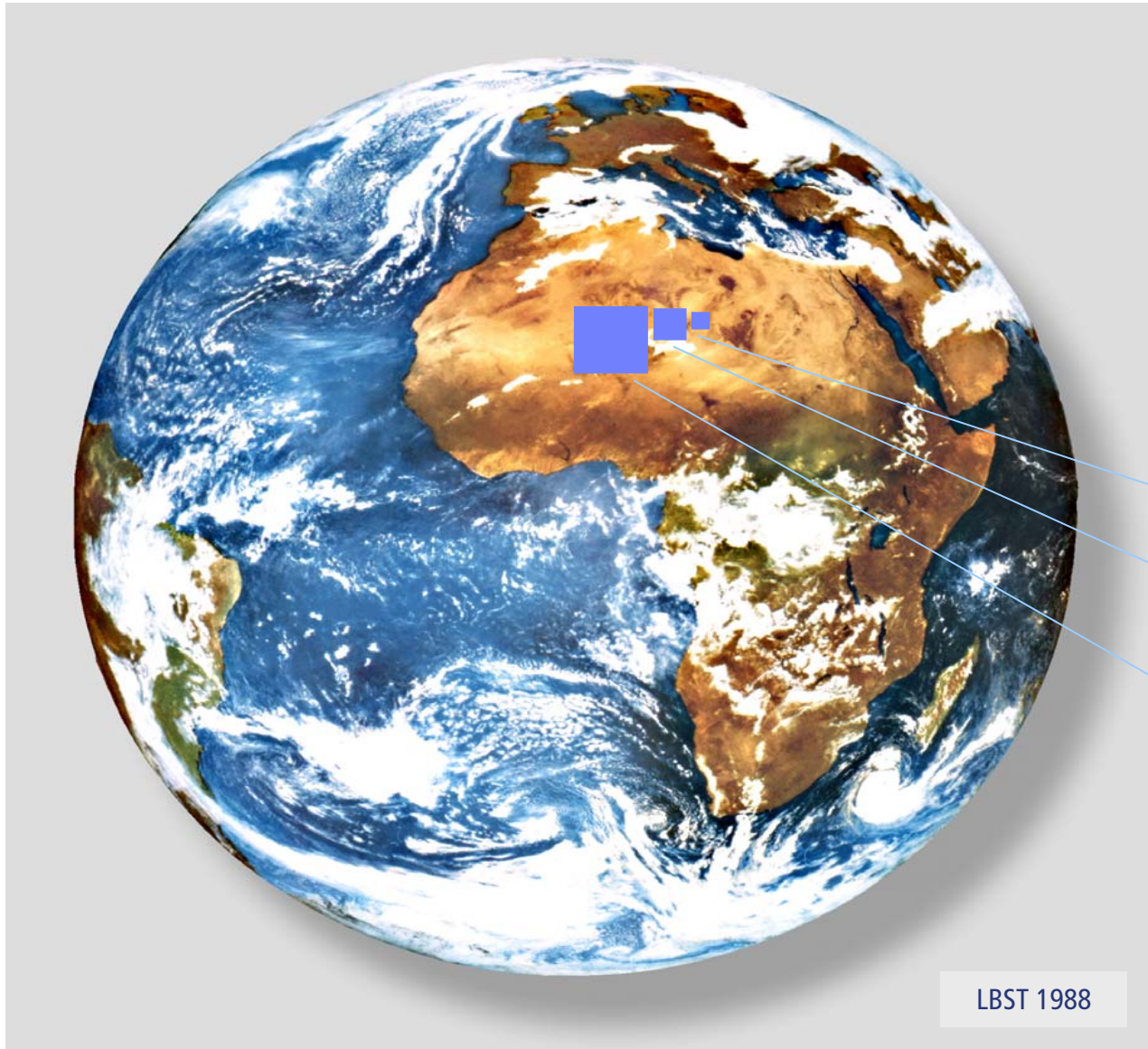


- (1) Roofs plus 0.1% of the total land area in EU 27
- (2) Residues plus 10% of the arable land in EU 27

Supplying Energy Demand by Solar



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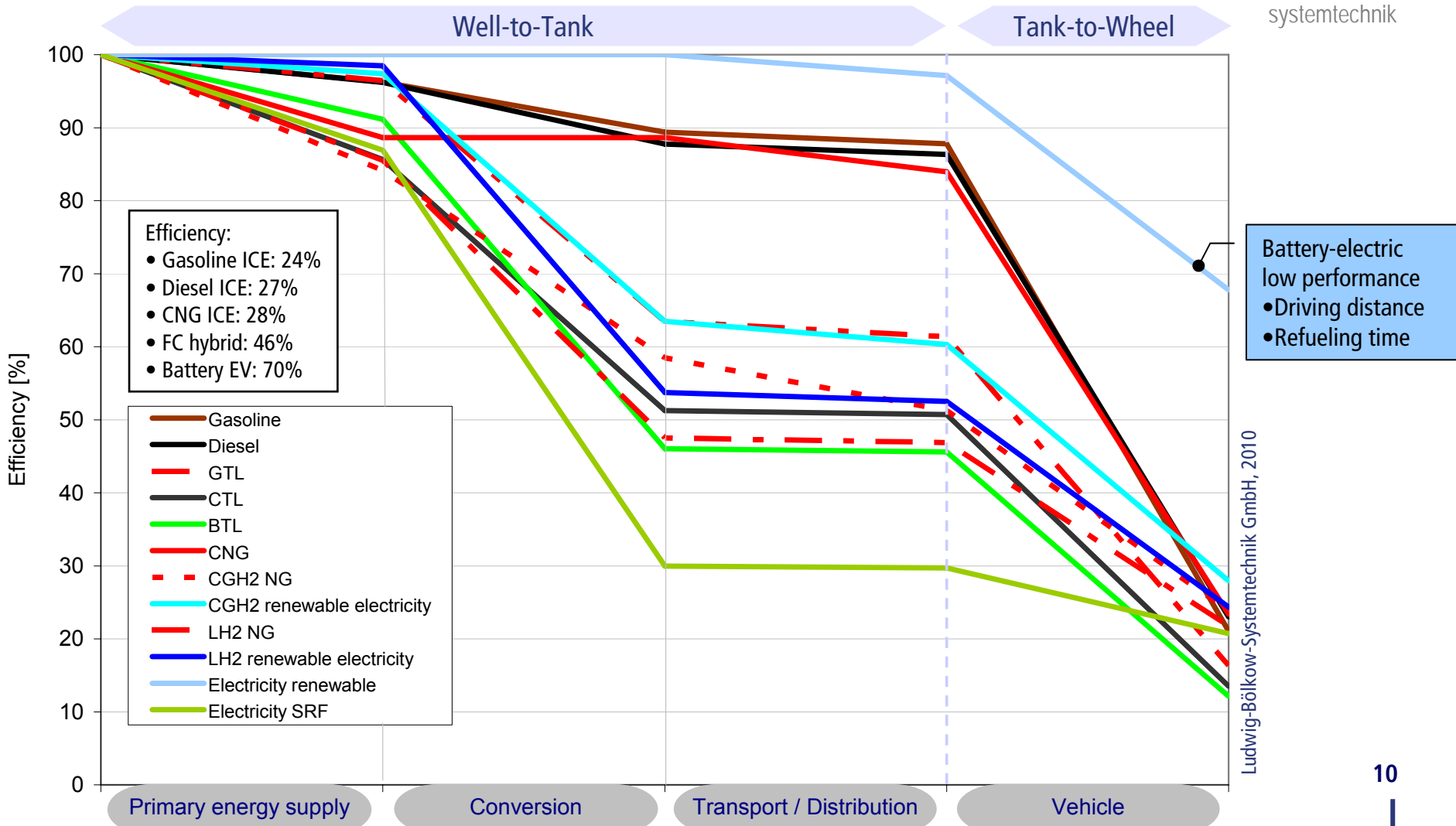
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Greenhouse Gas & Pollutant Emissions

Efficiency chains of fuel/ vehicle technologies



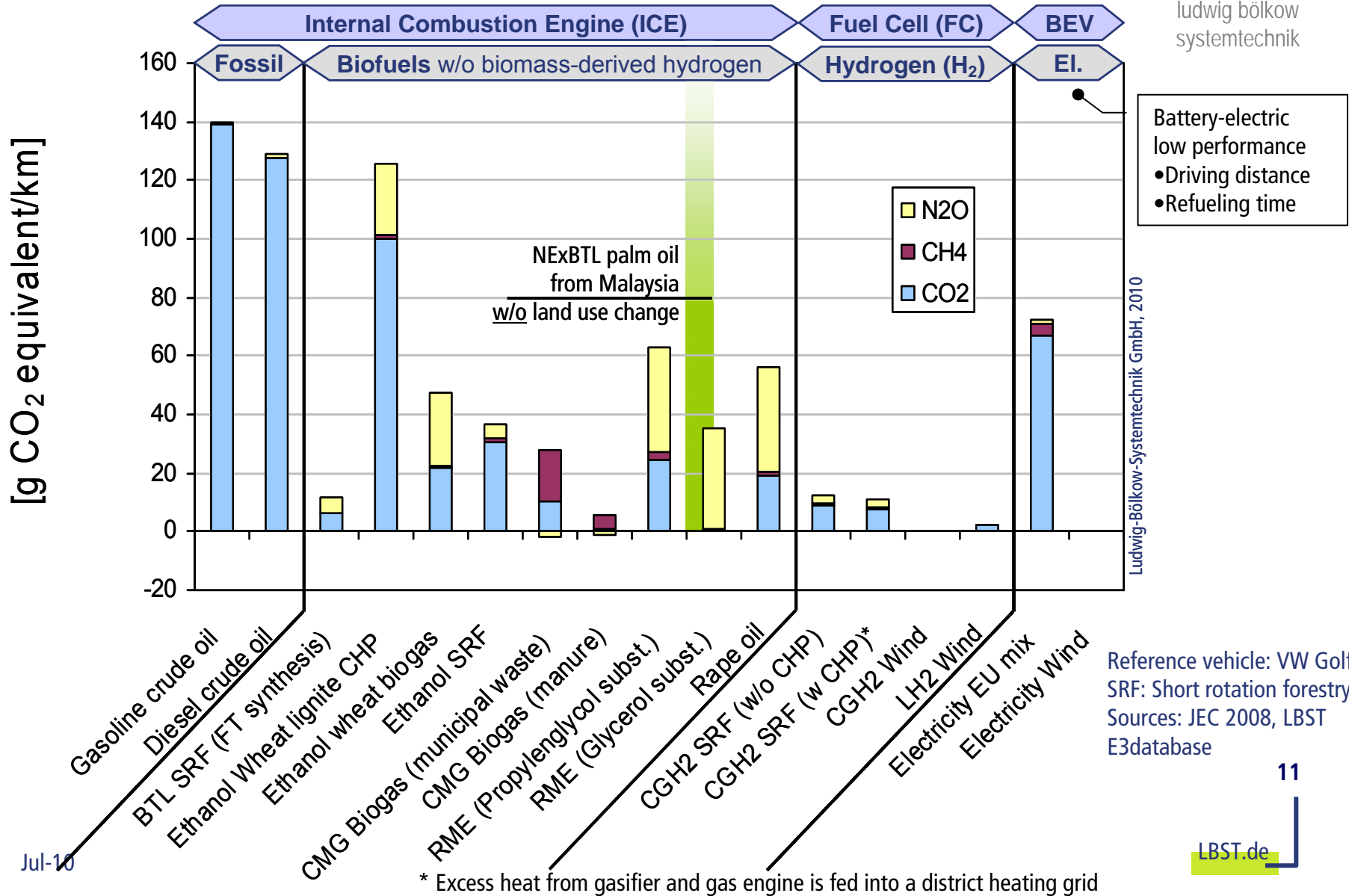
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GHG emissions Well-to-Wheel w/o land use change



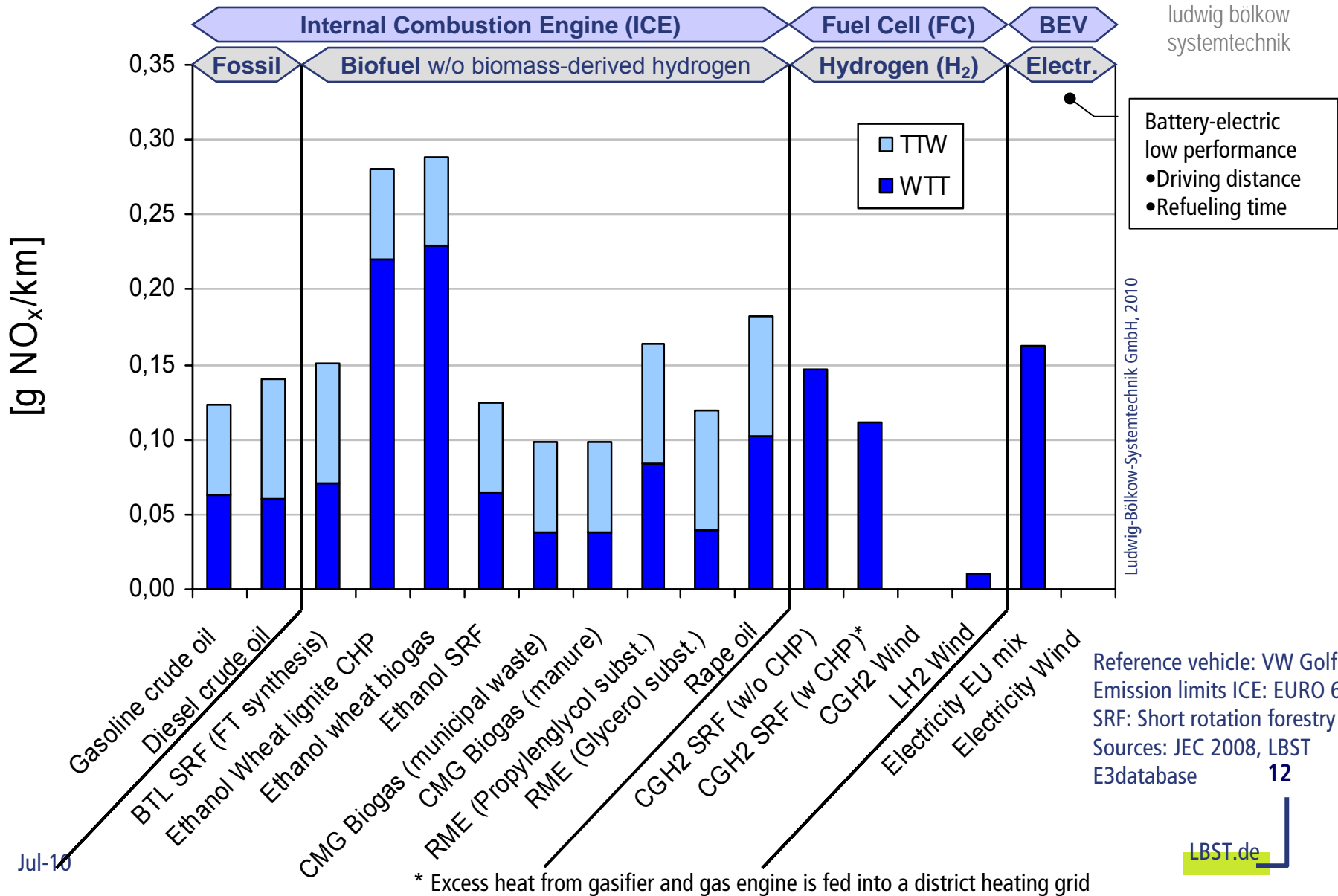
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NO_x emissions Well-to-Wheel



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Reference vehicle: VW Golf
Emission limits ICE: EURO 6
SRF: Short rotation forestry
Sources: JEC 2008, LBST
E3database

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



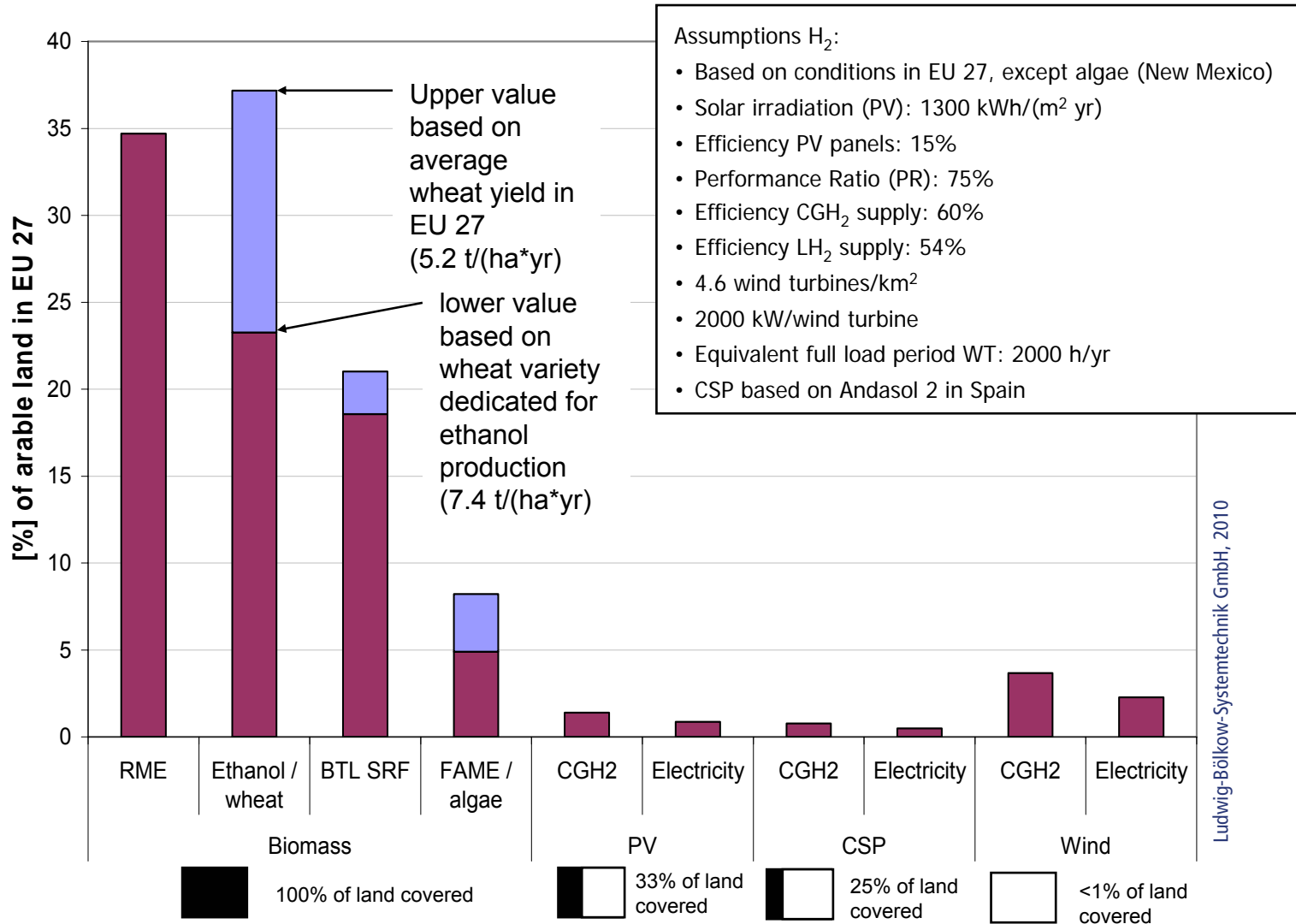
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Land-use

Land requirement to provide 10% transport fuel



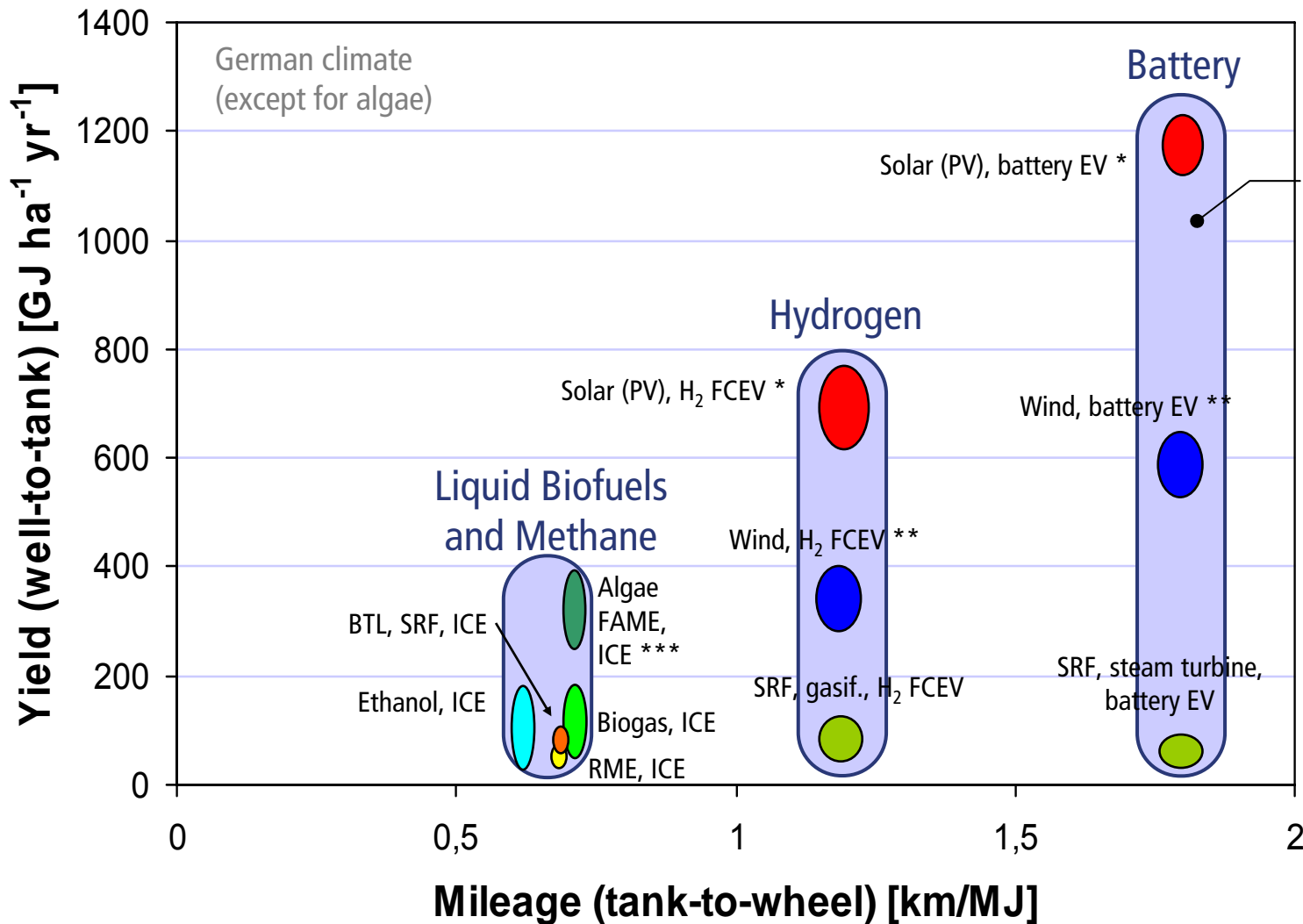
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Key performance criteria: "mileage" versus "yield"



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

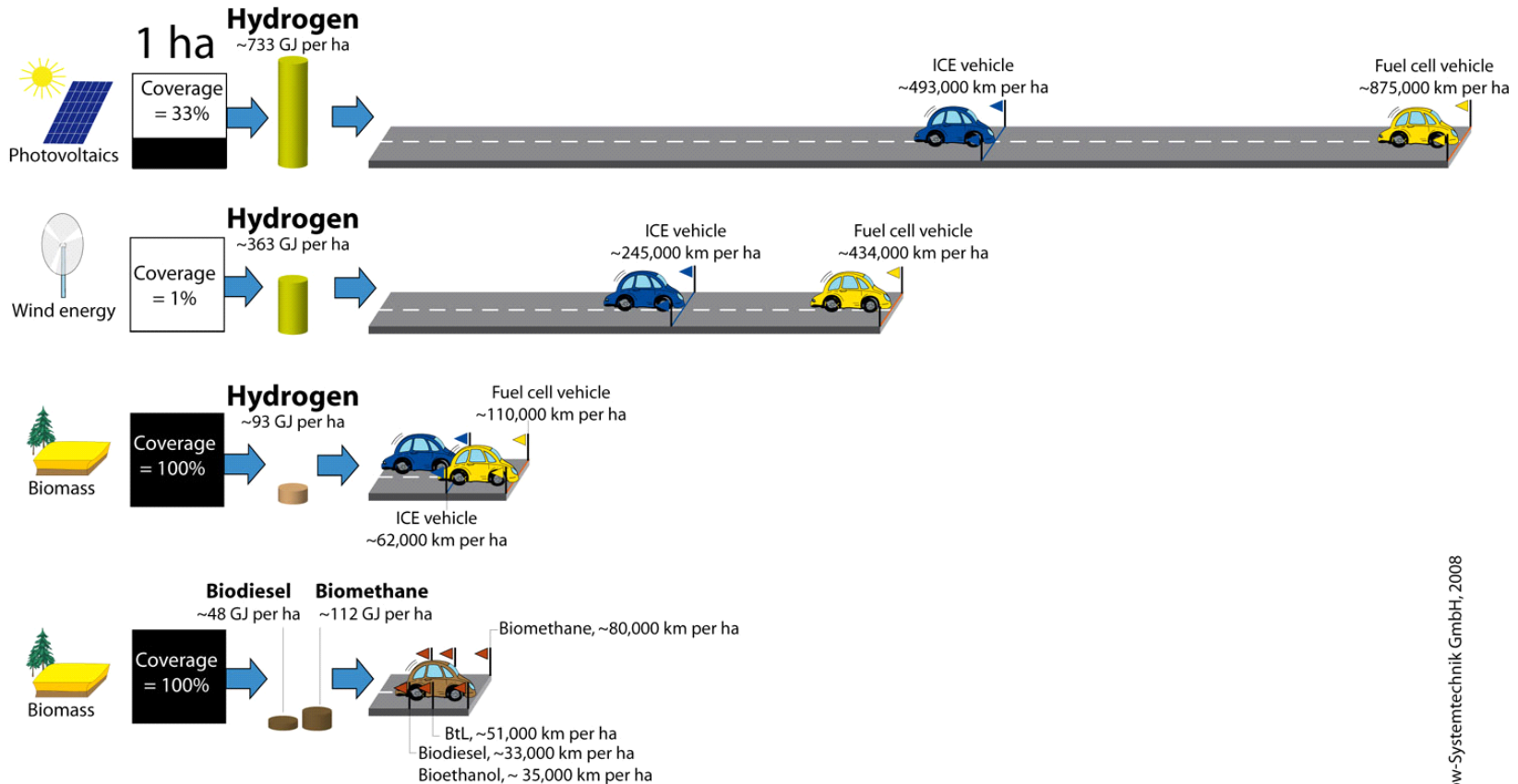
**) more than 99% of the land area can still be used for other purposes e.g. agriculture

***) region with high solar irradiation

Driving distance with fuel from one hectare of land



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Primary energy	Land covered	Fuel production per ha	Well-to-Wheel efficiency (vehicle km per ha)
Photovoltaics	1 ha	~733 GJ per ha Hydrogen (Coverage = 33%)	ICE vehicle: ~493,000 km per ha Fuel cell vehicle: ~875,000 km per ha
Wind energy	1 ha	~363 GJ per ha Hydrogen (Coverage = 1%)	ICE vehicle: ~245,000 km per ha Fuel cell vehicle: ~434,000 km per ha
Biomass	1 ha	~93 GJ per ha Hydrogen (Coverage = 100%)	ICE vehicle: ~62,000 km per ha Fuel cell vehicle: ~110,000 km per ha
Biomass	1 ha	~48 GJ per ha Biodiesel, ~112 GJ per ha Biomethane (Coverage = 100%)	Biodiesel: ~33,000 km per ha Bioethanol: ~35,000 km per ha Biomethane: ~80,000 km per ha BtL: ~51,000 km per ha

ha = hectare
ICE = internal combustion engine

Reference vehicle: VW Golf [Concawe/EUCAR/JRC 2006], average driving performance = 12,500 km per year

Ludwig-Bölkow-Systemtechnik GmbH, 2008



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Water

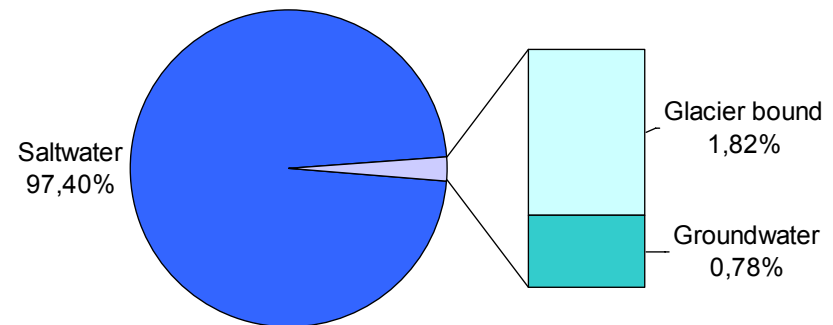
World Water Demand and Sources



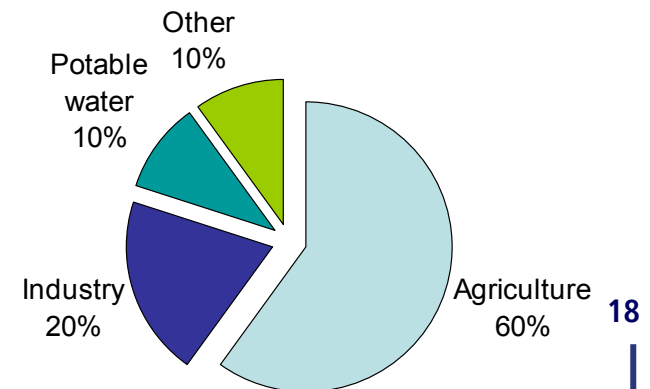
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- World water consumption has increased 100 times over the last 100 years
- Currently, some 5,500 km³ are consumed every year
- Thereof, some 3,300 km³ are taken from various reservoirs
- Less than 50% of water consumption stems from natural rainfall
- 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

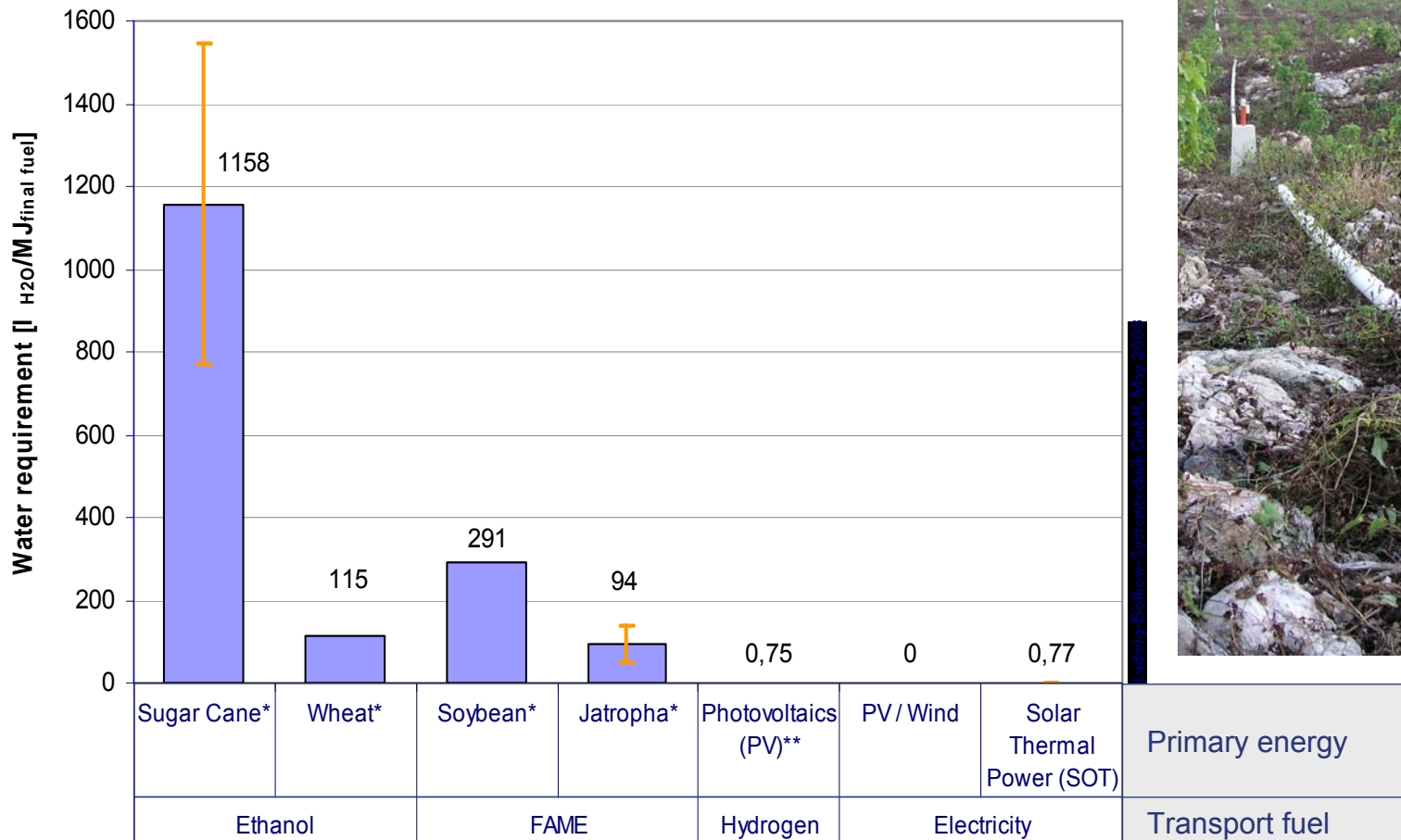


Water Intensity of Transportation Fuels



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- 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



Bioenergy spray irrigation
Photo: LBST

Jul-10

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



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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

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 with respect to **land-use** to any of the biofuel production pathways, which are in strong land-use competition with the production of biomass for food, feed, heating and construction material
- ▶ Biofuels' **water requirements** (sensitive to local climatic conditions) is in general several orders of magnitude higher than for hydrogen from renewable power
- ▶ Comprehensive **life-cycle analyses** are required for assessing the sustainability of alternative transportation fuels with biofuels being the most complex
- ▶ 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
- ▶ **The importance of sustainability issues for transport fuels is strongly increasing**

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Thank you for your attention!



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Company Profile

- Expert consultants for energy and environment – strategy, technology, sustainability
- Serving international clients in industry, finance, politics, and NGOs
- Cutting edge competence, interdisciplinary, over two decades of continuous expertise
- Rigorous system approach, global and long term perspective
- Focus on
 - Energy (renewables, energy storage, hydrogen and fuel cells)
 - Mobility (fuels and drives, infrastructure, mobility concepts)
 - Sustainability

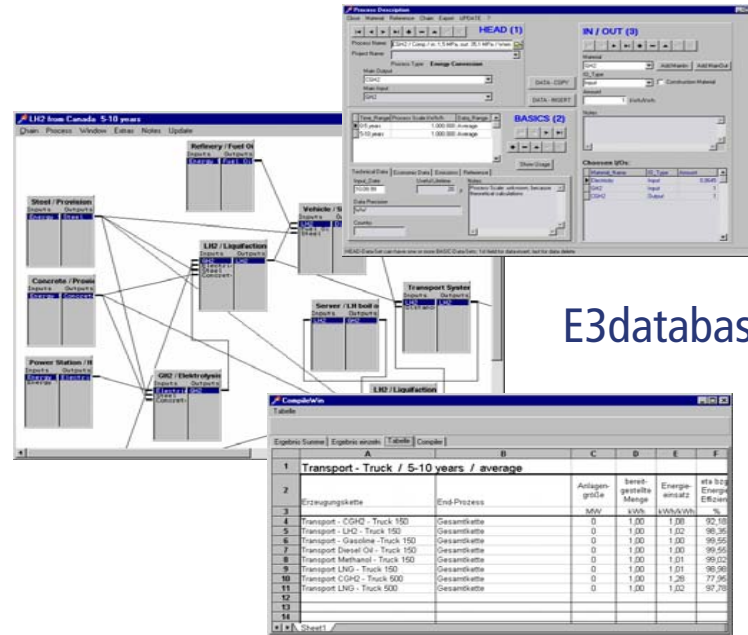


E3 database

A calculation tool

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

- Emissions of greenhouse gases (CO₂, CH₄, etc.) and air pollutants (CO, PM, VOC, etc.)
- Free definition of environmental key performance indicators
- Cumulative energy demands
- Material balances, e.g. for the construction of an industrial plant
- Economic aspects such as investment costs, operation and maintenance costs, depreciation conditions, etc.



E3database.com

