Fuels for Sustainable Mobility – a European perspective

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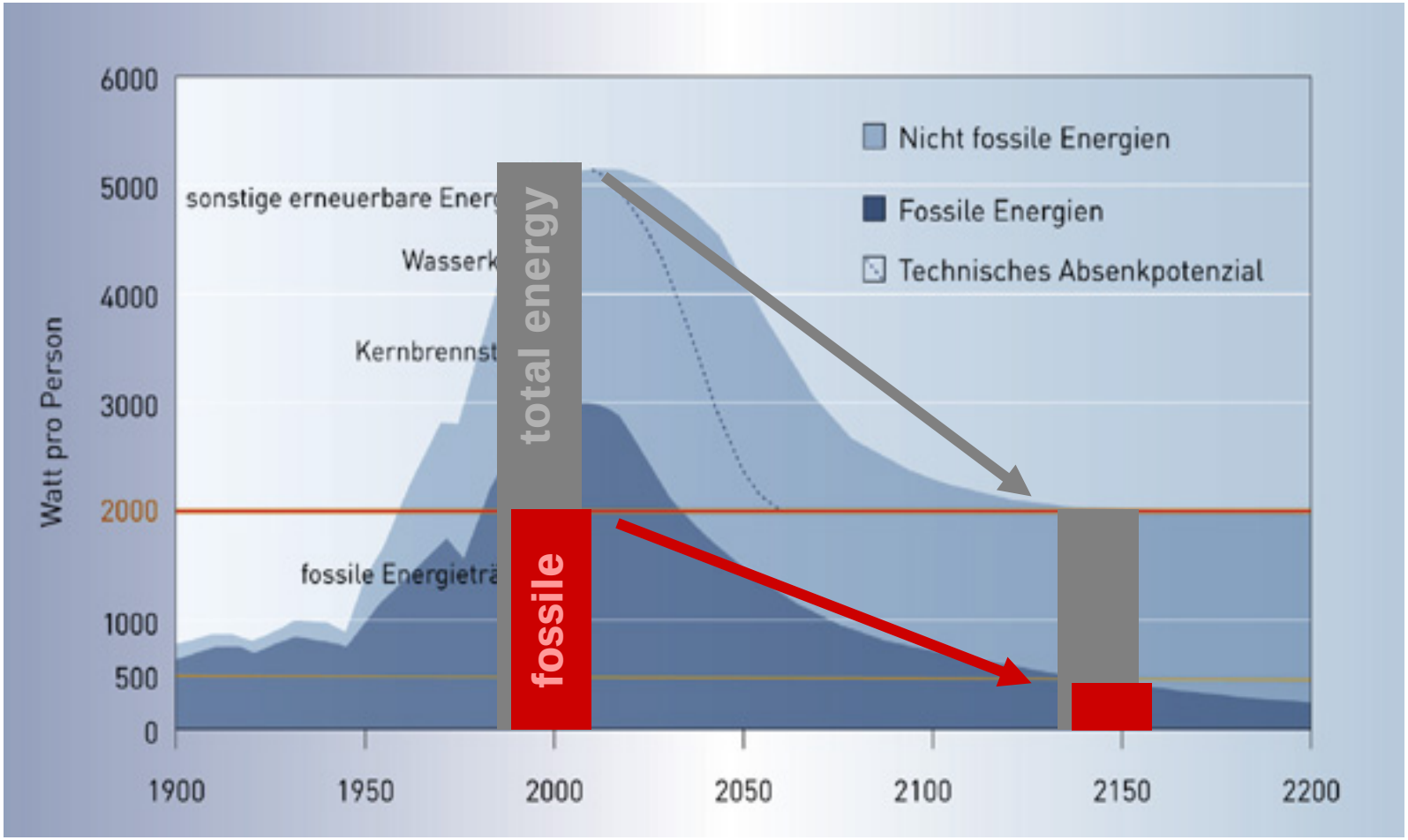
Fuels for Sustainable Mobility – a European perspective

- The challenge of sustainable mobility
- Biofuels
- Hydrogen
- Electricity
- Synthesis

Future mobility – the major challenges

- ~~Air pollution (PM, SO2, NOx, ...)~~
  - technologically solved
  - zero emission is feasible
- **Oil depletion**
  - depletion midpoint 2007-15
  - increasing consumption (e.g., China)
  - increasing dependency on middle-east
- **Climate change**
  - scientifically proven
  - long-term effects unknown

2000W society: energy reduction path



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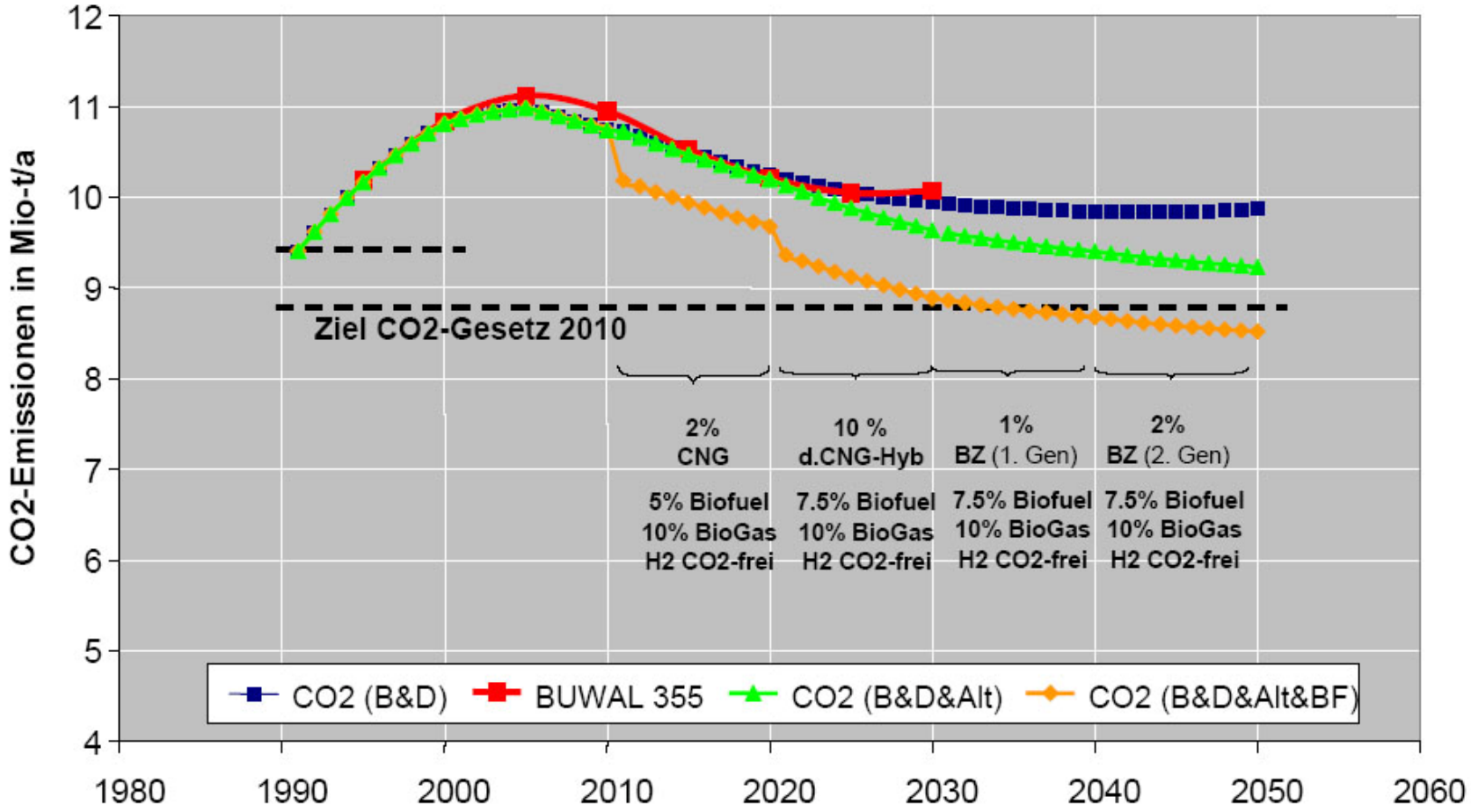
Emissionsprognosen in der Mobilität
(C. Bach, 1.3.05, EnergieSchweiz)



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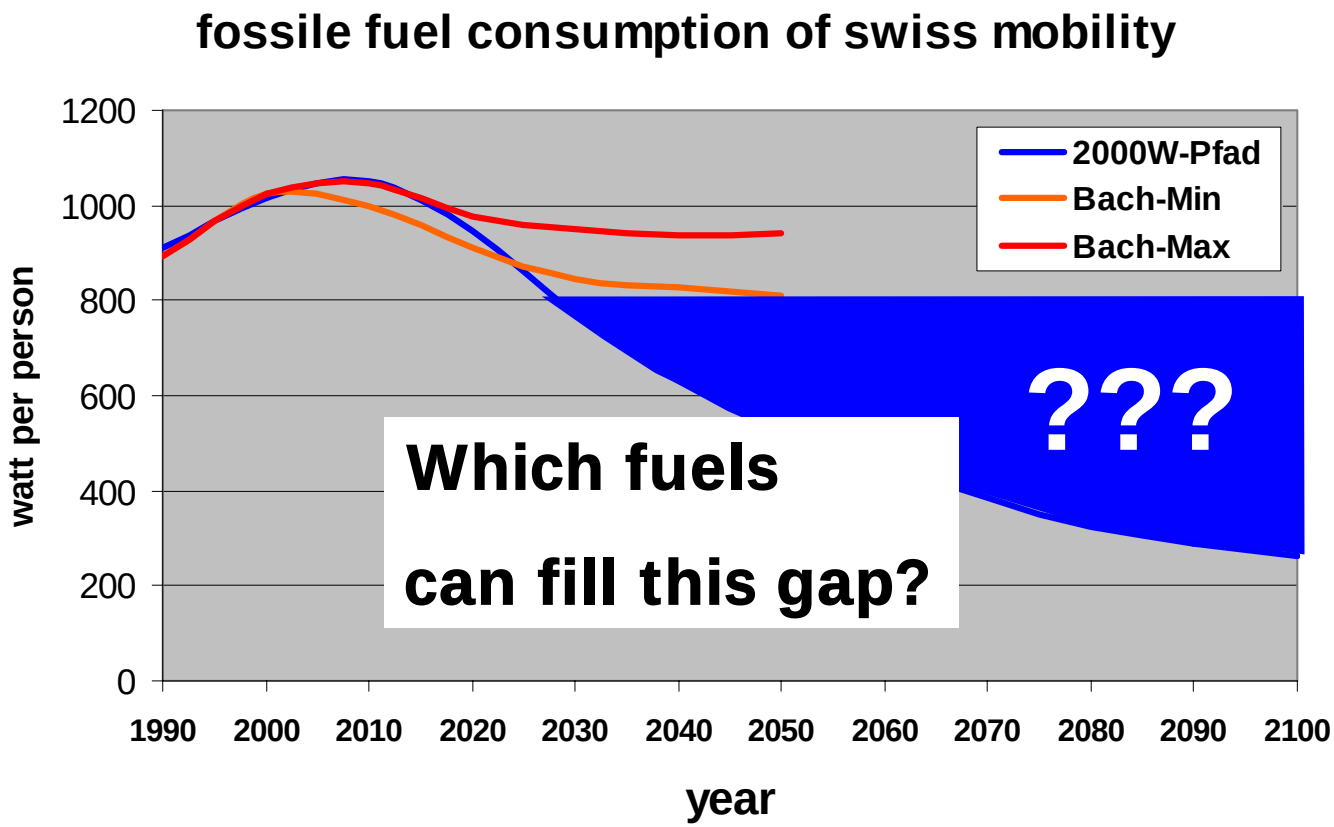
2000W-pathway vs. Future mobility?



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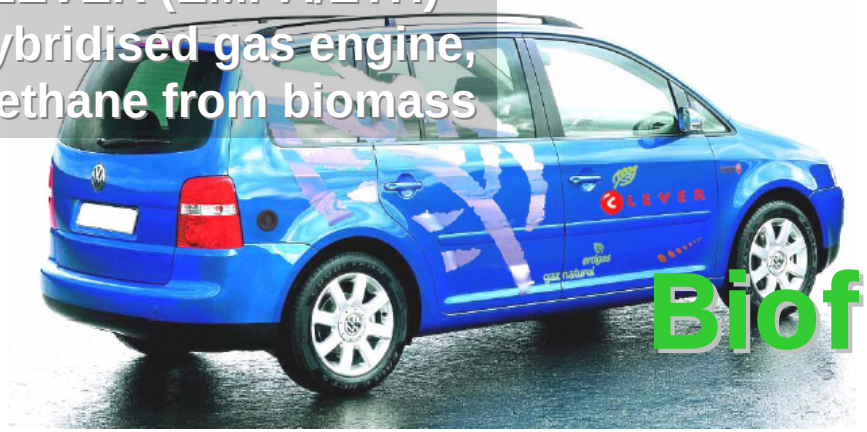
Boundary conditions for sustainable mobility

- CO_2-neutral energy supply
- High energy efficiency of cars
- no rebound effects (e.g., on working places or biodiversity)

suitable technologies

CLEVER (EMPA/ETH)
Hybridised gas engine,
methane from biomass



SunFuel (Volkswagen)
highly efficient TDI engine,
biomass-to-liquid

Biofuels

Hydrogen

HyLight (Michelin/PSI)
FuelCell-light weight car,
H_2 from photovoltaics

CleanEnergy (BMW)
H_2 direct combustion
H_2 from photovoltaics

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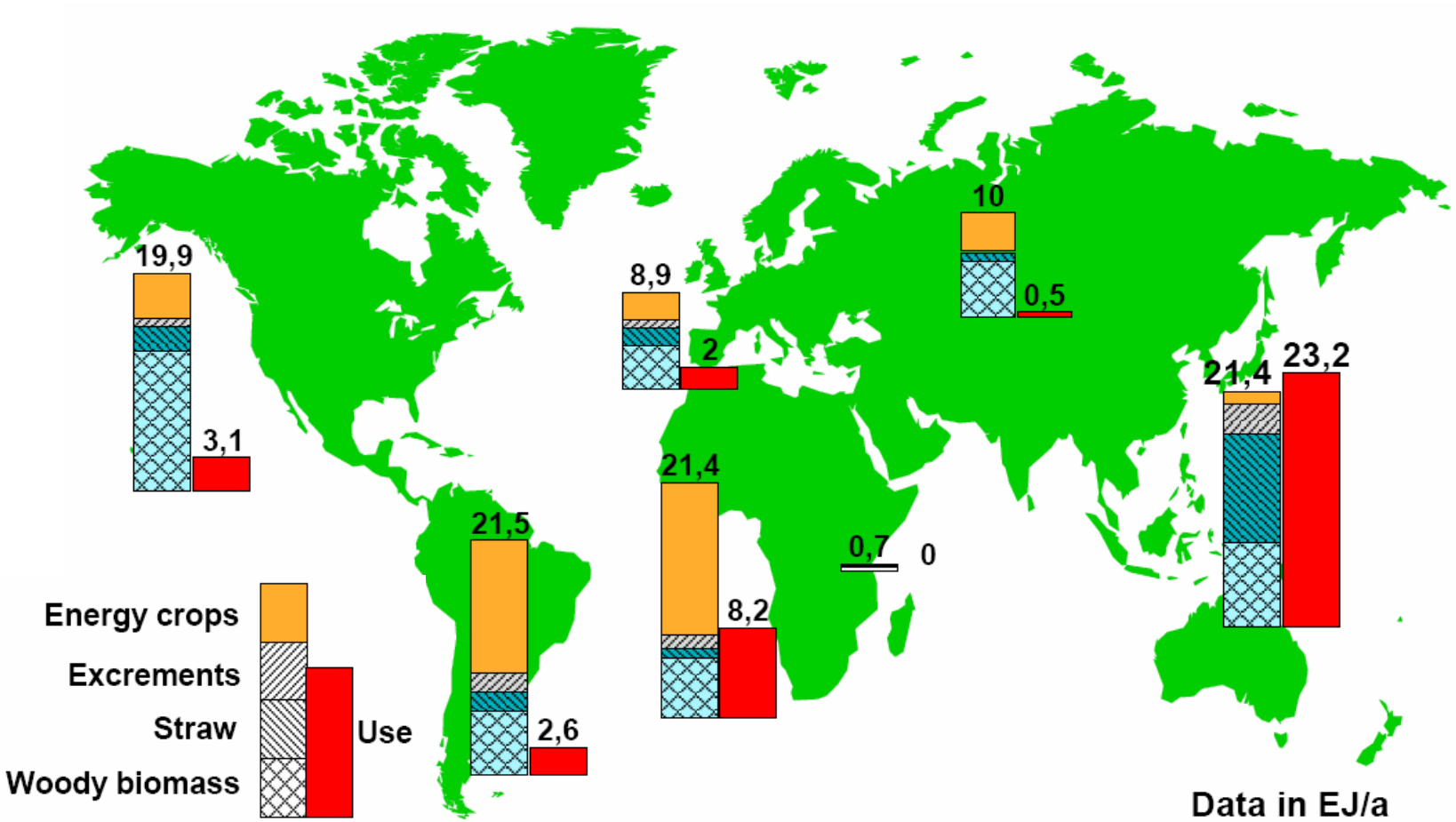
Energy from biomass
large potential – little use



http://www.german-renewable-energy.com/downloads/pdf/energy_from_biomass_india.pdf

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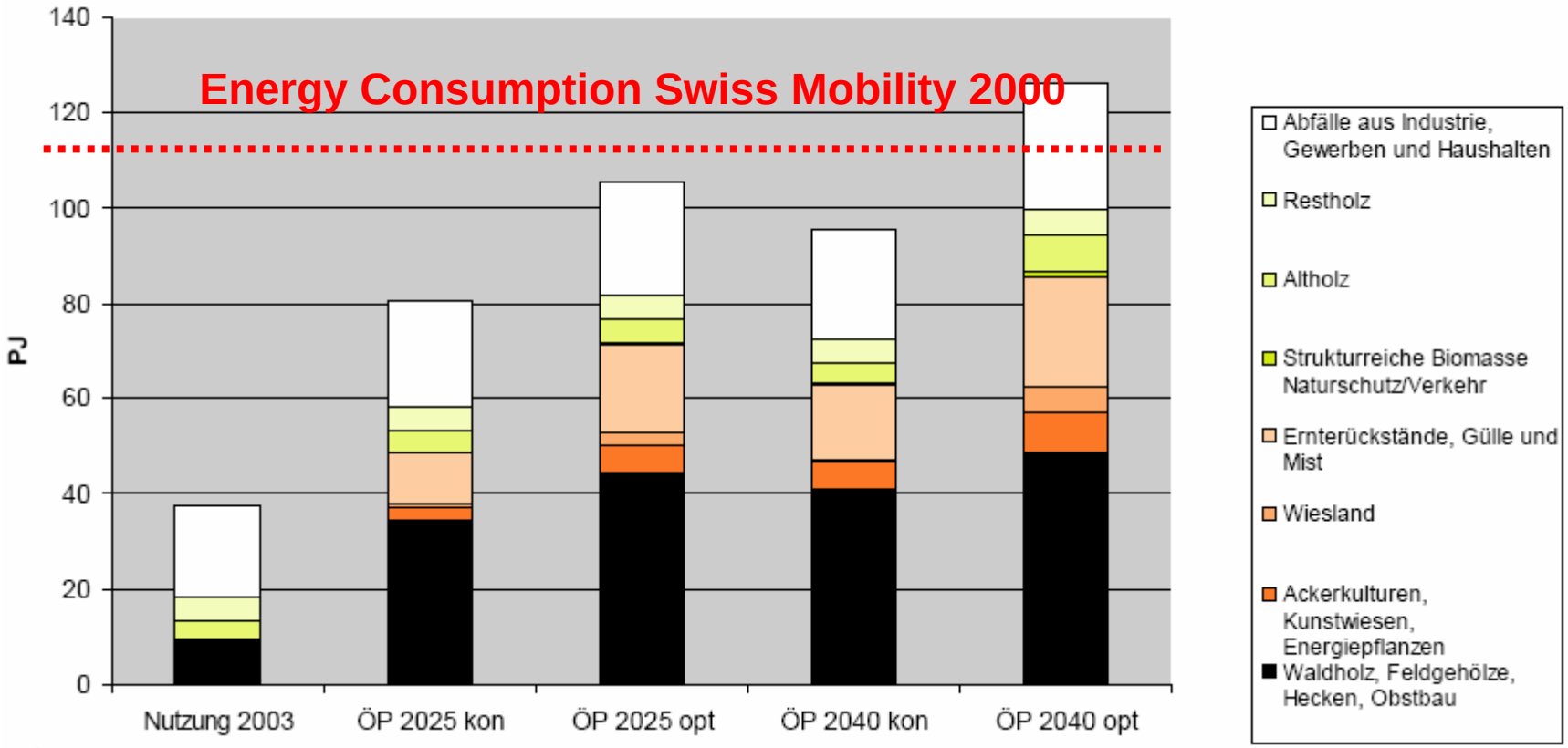
Biomass potential in Switzerland 2025/2040



(Oettli et al., 2005, Potentialabschätzung Biomasse, BFE)

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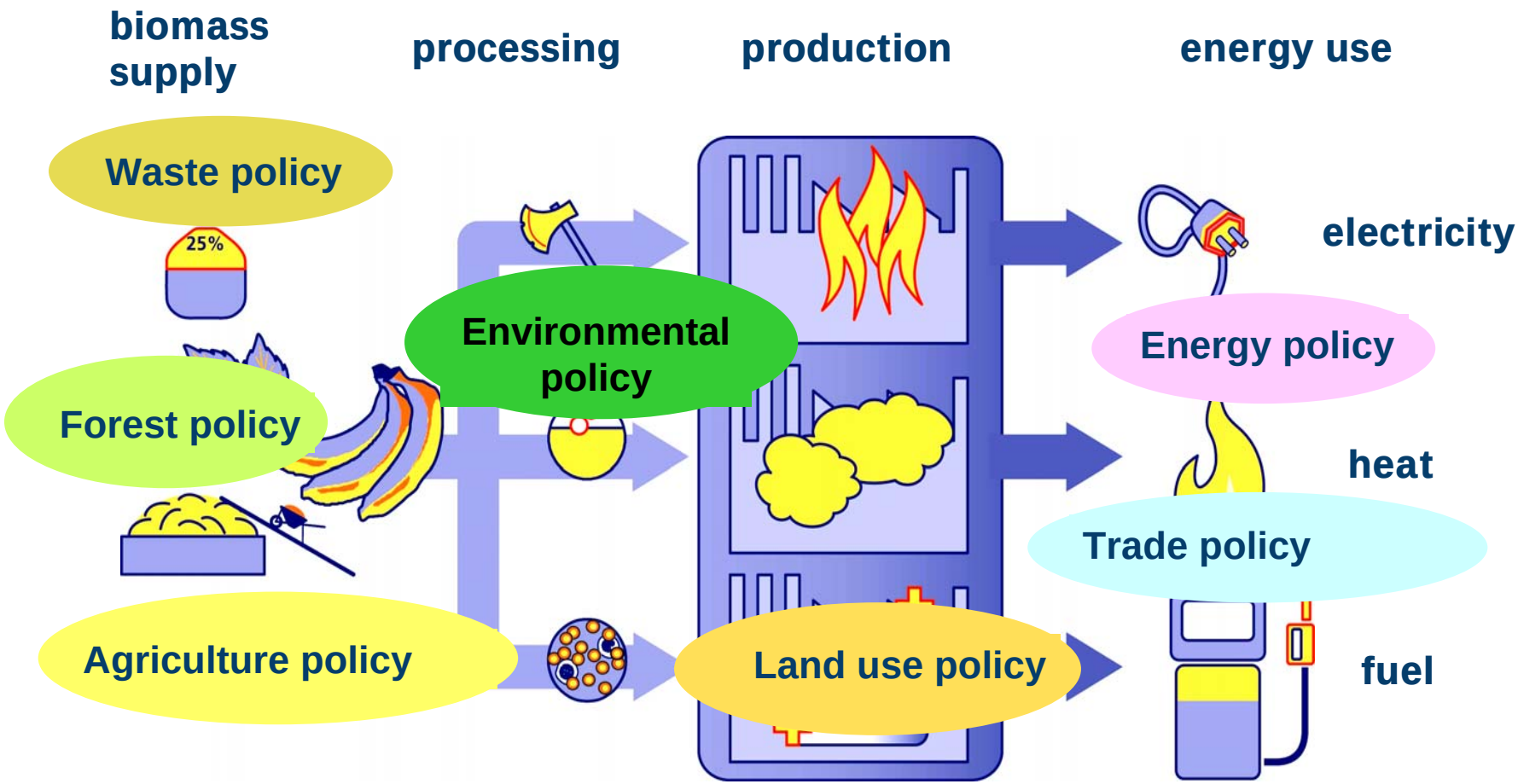
Energy from biomass
complex boundary conditions



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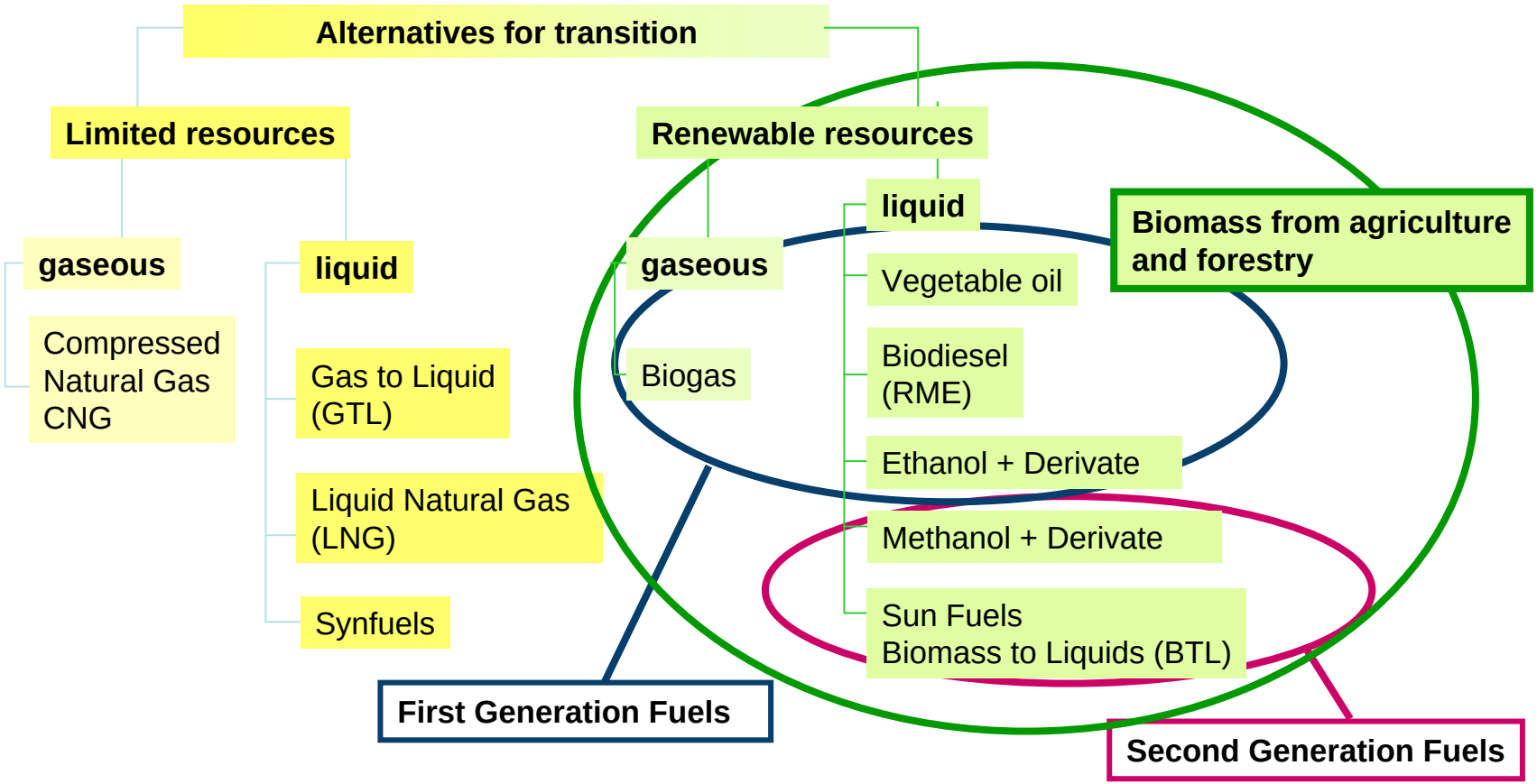
Biofuels
process technologies



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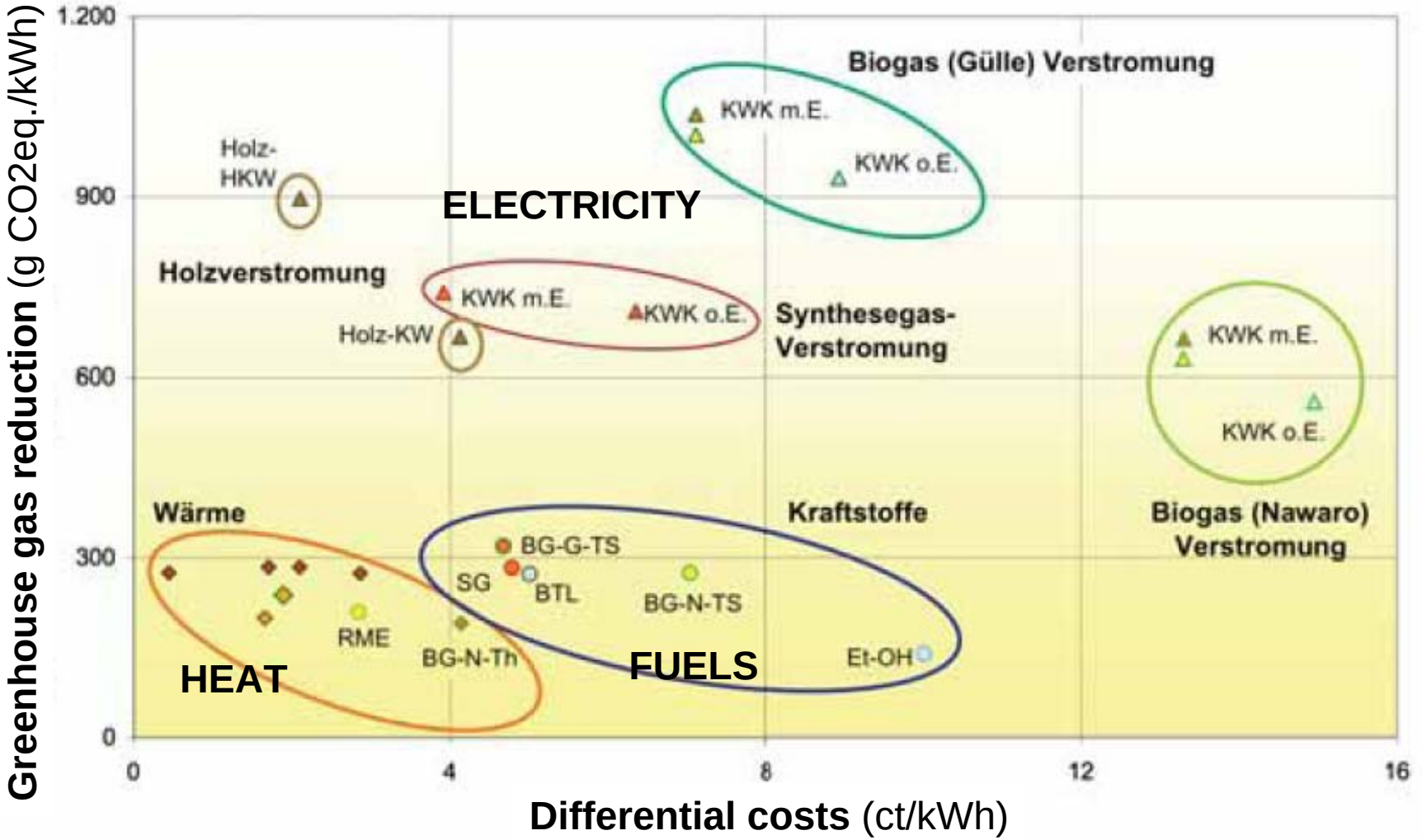
Bioenergy: GHG reduction vs. costs



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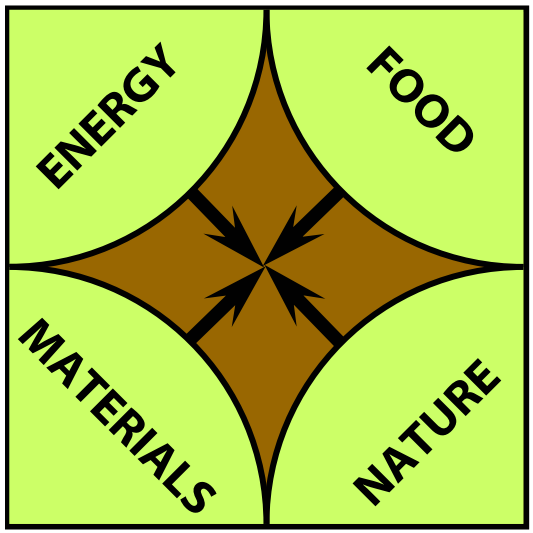
Biofuels: potential conflicts

- **Bioenergy production might lead to land use conflicts…**



Land area

TA, 30.3.05

Hohe Benzinpreise verteuern Zucker

Zürich. – Während Jahren war der Zuckerpreis einem steten Auf und Ab ausgesetzt. Doch als er im Februar mit 9,23 Cent je Pfund eine neue Rekordmarke erreichte, fiel er – im Gegensatz zu früher – nicht zurück. Der Grund für die anhaltende Zucker-Hausse liegt ausgerechnet im hohen Benzinpreis. Denn dadurch sehen sich immer mehr Länder gezwungen, alternative Energien zu fördern. So etwa Brasilien, das gut die Hälfte der Zuckerrohrernte zu Ethanol verarbeitet und damit bereits heute 26% seines Treibstoffbedarfs deckt.

Sollte sich die brasilianische Pe-

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Biofuels: potential conflicts

… or to regional conflicts:

- Local use of energy?

or

- Production of energy at most efficient sites for export?

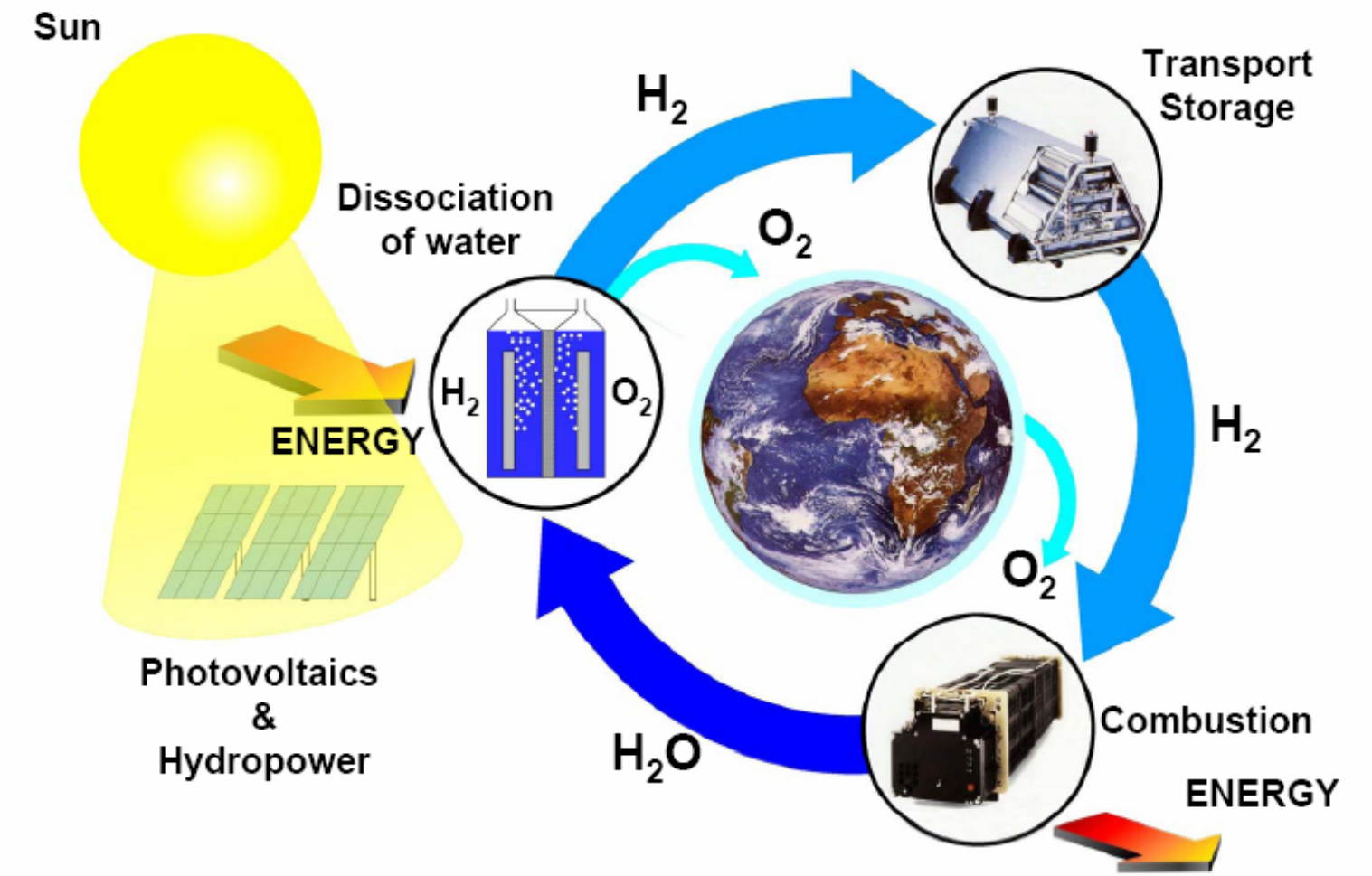
→ Production of Bioethanol in Brasil

Potential of Biofuels?

- Technologies are already in use (Biogas, Biodiesel, Bioethanol)
- 2nd Generation will come soon (BTL, wood to biogas)
- Conventional car technologies can be used

- Limited amount (approx. 20 % of European energy consumption)
- Land use impacts
- Efficiency of power generation > fuel production

The Hydrogen cycle



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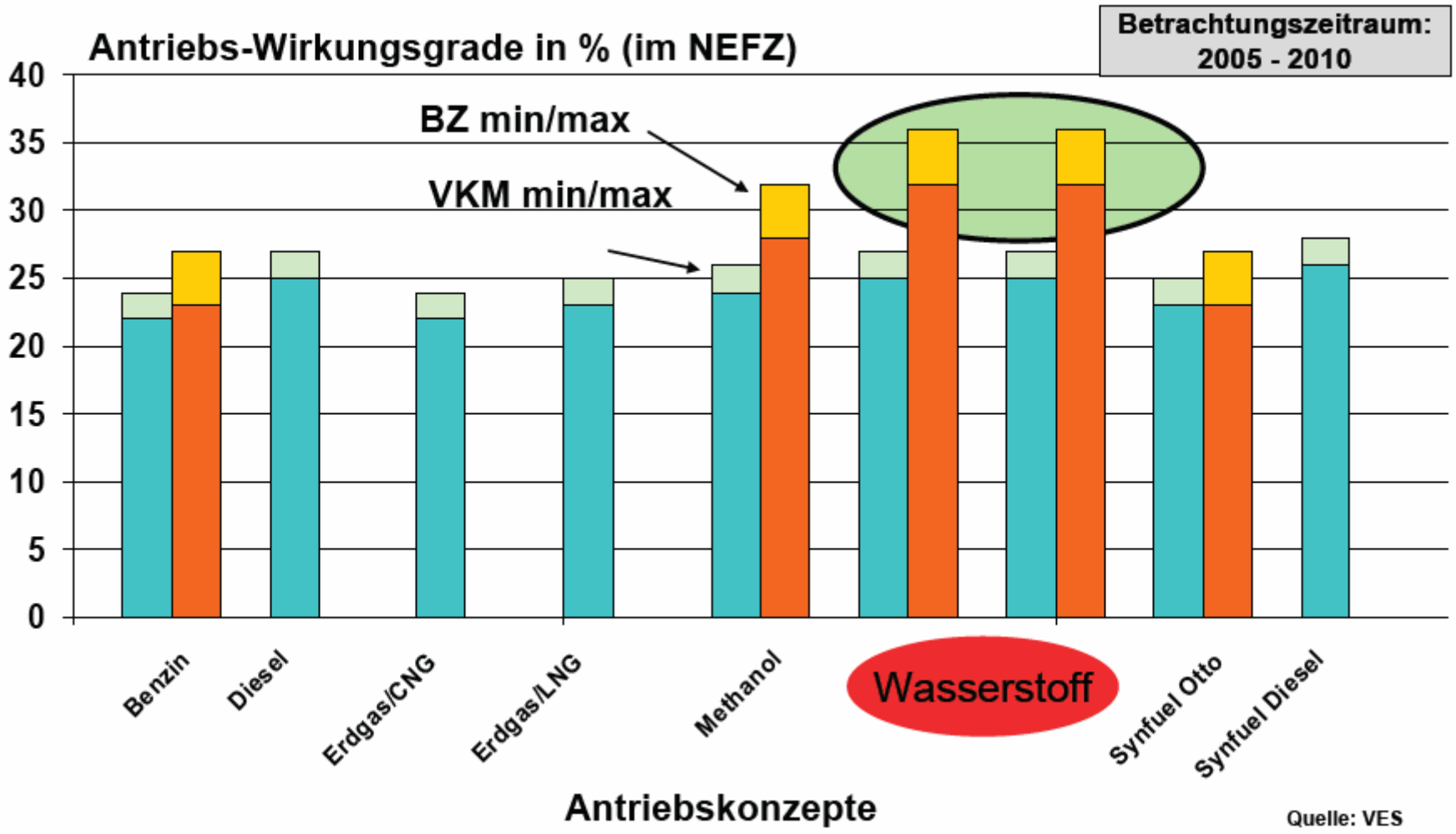
Hydrogen: higher efficiency



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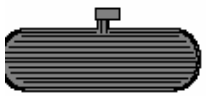
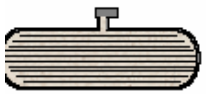
Hydrogen: the storage problem

HYDROGEN STORAGE

	Storage Media	Volume	Mass	Pressure	Temperature	
	molecular H_2	max. 33 kg $H_2 \cdot m^{-3}$	13 mass%	800 bar	298 K	Composite cylind. *established*
	molecular H_2	71 kg $H_2 \cdot m^{-3}$	100 mass%	1 bar	21 K	Liquid hydrogen
	molecular H_2	20 kg $H_2 \cdot m^{-3}$	4 mass%	70 bar	65 K	Physisorption
	atomic H	max. 150 kg $H_2 \cdot m^{-3}$	2 mass%	1 bar	298 K	Metalhydrides
	atomic H	150 kg $H_2 \cdot m^{-3}$	18 mass%	1 bar	298 K	Complex hydrides *reversibility ?*
	atomic H	>100 kg $H_2 \cdot m^{-3}$	14 mass%	1 bar	298 K	Alkali + H_2O

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Potential of Hydrogen

- Fully sustainable (if production is CO2-neutral)
- Unlimited availability
- High efficiency tank-to-wheel

- Storage problems are not solved
- Infrastructure is missing
- Cost-efficient CO2-neutral H2 production not available yet

→ Long term solution

Renewable Energy Conversion

η = 0.85 (Hydro. 66%)
η = 0.5 (Wind 1%)
η = 0.1 (Solar. 100%)

η = 0.7

1.2 kWh/kg
5000 kWh/m³

ideal Zn/air

η = 0.9

η = 0.63

Battery

18 mass%
150 kg H_2/m³

7 kWh/kg
5800 kWh/m³

η = 0.9

H_2

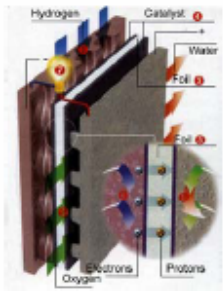
O_2

H_2

O_2

H_2O

η = 0.85

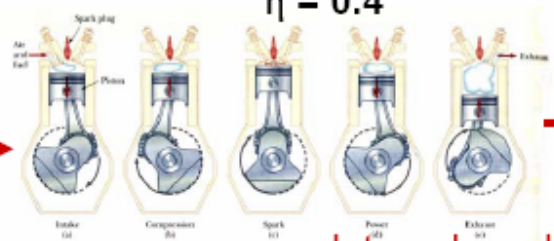


η = 0.6

η = 0.46

Fuel Cell

η = 0.4



η = 0.31

Internal combustion engine

Gasoline:
13 kWh/kg
10'000 kWh/m³

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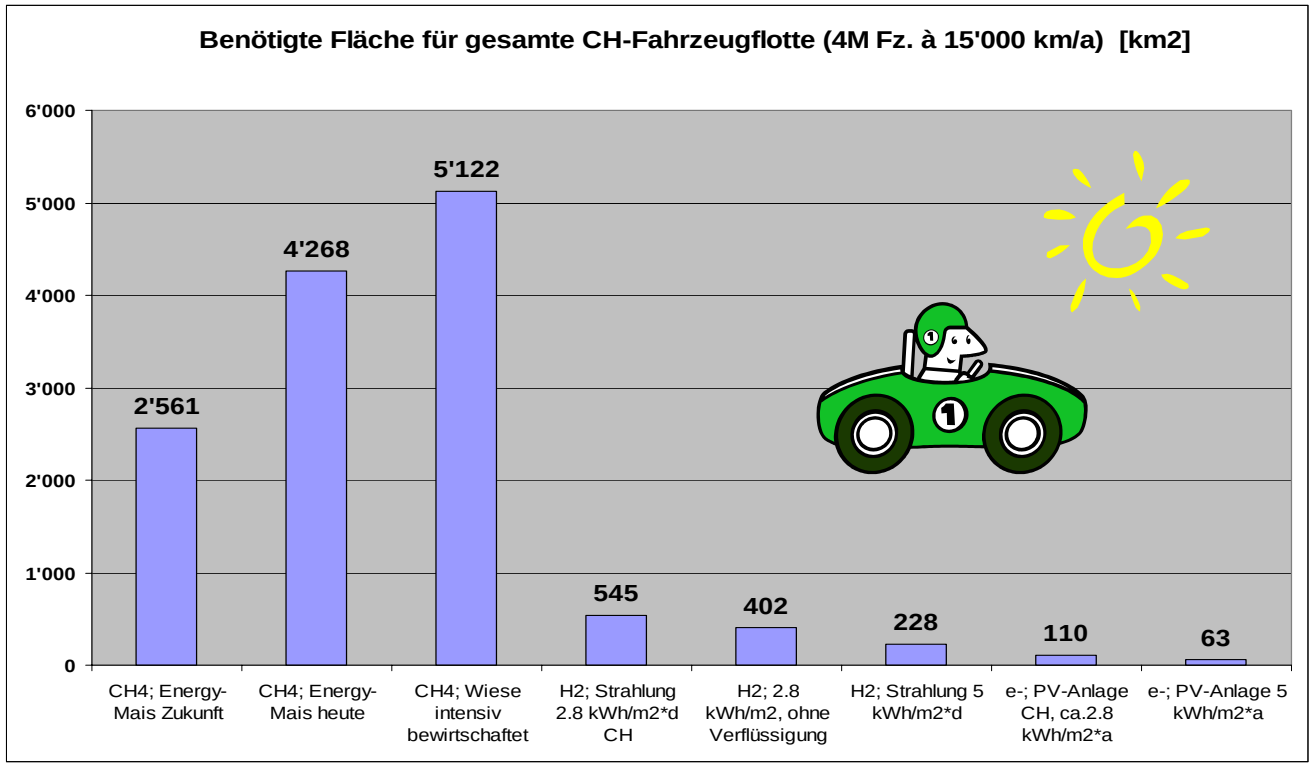
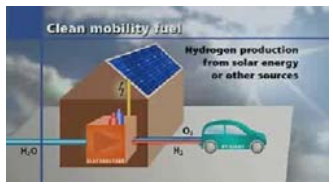
Land area for mobility generation?





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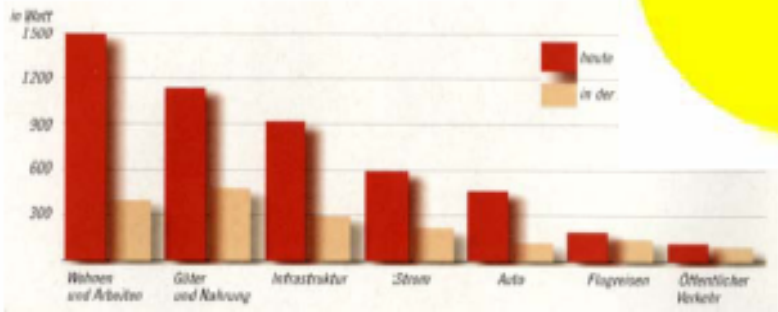
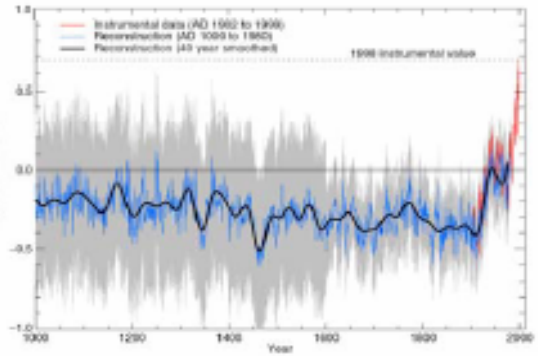
CONCLUSION



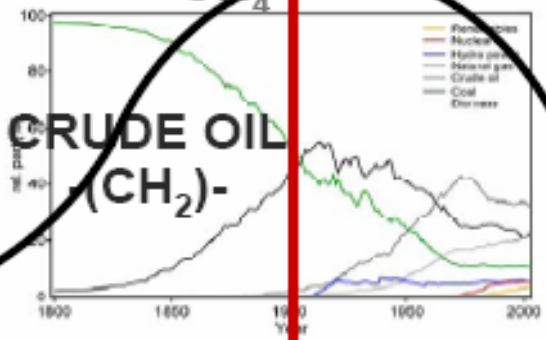
BIOMASS
$-(CH_2)-$

BATTERIES

HYDROGEN
H_2



NATURAL GAS
CH_4



CRUDE OIL
$-(CH_2)-$

COAL
C

today

Time