LAMNET, Rome, May 2004

Global Biomass Resources for Innovative Synthetic Fuels

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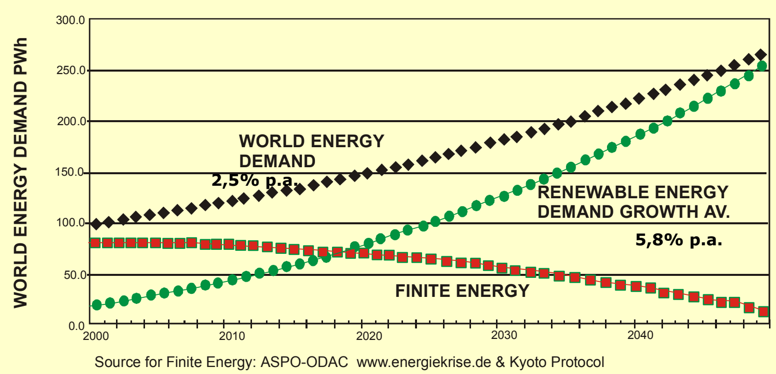
„We are approaching the point where the energy consumption for exploration and transportation outside the Middle East is higher than the energy which is extracted from it. Our national economies should be steered by energy balances and not mainly through monetary dimensions. Money is relative and transient, but energy is essential and eternal. We should realise that problems of energy, environment, climate and development are interconnected".

	Alexander King, Former President of the Club of Rome (1985)	Pflanzenbau FAL/El Ba 1999

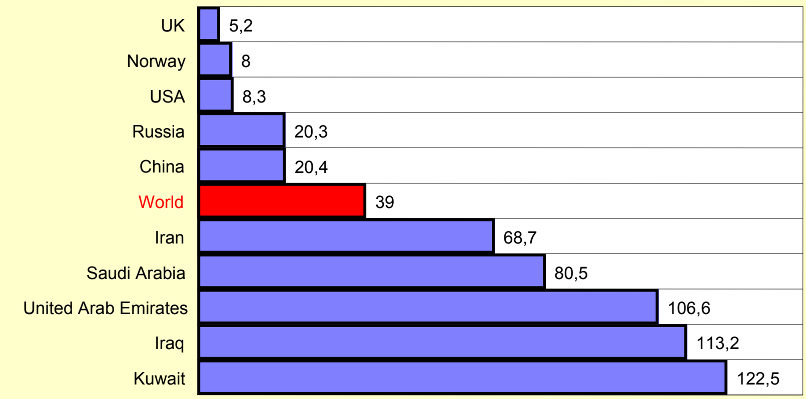
G. H. Brundtland (1987)

„We need to conserve some of the fossil fuel resources for the future and create adequate substitutes in quantities which could meet the requirements of the people and enable future development.“ „ ... every effort should be made to develop the potential for renewable energy which should from the foundation of the global energy structure during the 21st century.“



Source for Finite Energy: ASPO-ODAC www.energiekrise.de & Kyoto Protocol

Pflanzenbau FAL/El Ba	World Energy Scenario 2000 - 2050	03 2636 2002



Pflanzenbau FAL/El Ba	Availibility of oil reserves in years - Oil extraction level: year 2000 -	03 2596b 2001

Fuels derived from biomass are not only potentially renewable, but are also sufficiently similar in origin to be the fossil fuels to provide direct substitution. They can be converted into a wide variety of energy carriers as of recent through conversion technologies, and thus have the potential to be significant new sources of energy into the 21st century.

The input/output energy balance ratio may reach up to 1:25. The CO_2 mitigation potential of energy crops as energy sources is considerably large.

Composition of Dry Biomass

Carbon	45%
Oxygen	42%
Hydrogen	6%
Others	7%

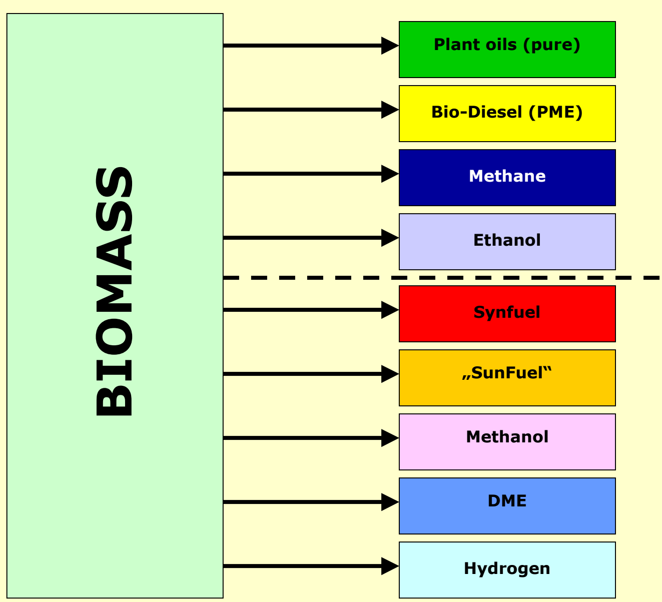
Global Biomass and Perspectives

- ***Annual primary biomass production: 220 billions DM, 4,500 EJ = 10 times of world primary energy consumption.***

  Biomass used for food: 800 millions DM = 0.4% of primary biomass production.
- ***Annual food production corresponds to 140% of the needs of world population.***
- ***Biomass currently supplies 14% of the worldwide energy consumption. The level varies from 90% in countries such Nepal, 45% in India, 28% in China and Brazil with conversion efficiency of less than 10%. The potential of improving this effiency through novel technologies is very high.***
- ***Large areas of surplus of agricultural in USA, EU, East Europe and former soviet countries and could become significant biomas producing areas (> 200 millions ha).***

- *Microalgae have the potential to achieve a greater level of photosynthetic effiency than most other forms of plant life. If laboratory production can be effectively scaled up to commercial quantities levels of up to 200 mt/ha/yr may be obtained.*
- *The efficiency of photosythetic is less than 1%. An increase in this efficiency (through genetic engineering) would have spectacular effects in biomass productivity: successful transformation of C_4-mechanism (from maize) to C_3-crops (rice). New achievement in accelarating cell division opens opportunities to speed up the growing seasons, resulting in several harvests per year and an overall increase in biomass.*
- *Developments in car technologies is leading to significant reduction in fuel consumption, i.e. less areas will be needed for more cars.*

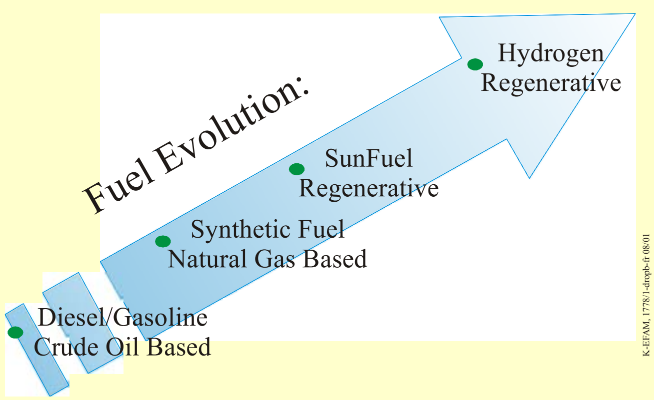
Transport Fuels



Combustion Process

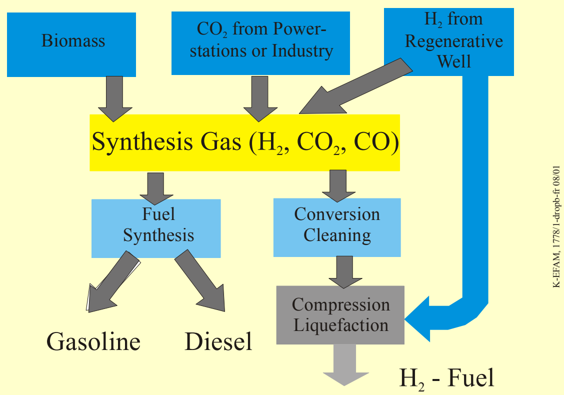
Oxygen supply characterized as □:

Pyrolysis	$\lambda = 0$
Gasification	$0 < \lambda < 1$
Combustion	$\lambda > 1$



Source: VOLKSWAGEN AG, Group Research

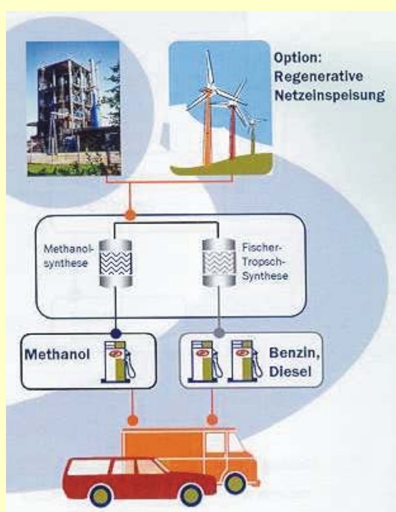
Pflanzenbau FAL/El Ba	VOLKSWAGEN Fuel Strategy	03 2591 2001



Source: VOLKSWAGEN AG, Group Research

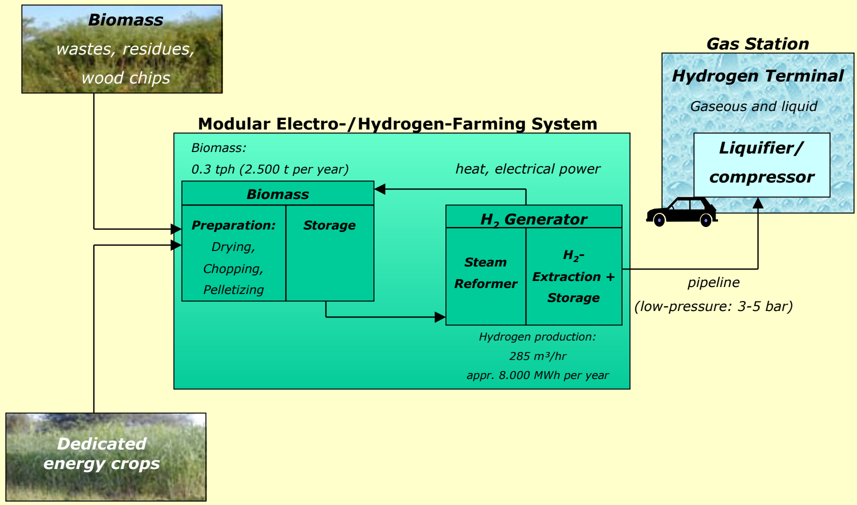
Pflanzenbau FAL/El Ba	Ways to CO_2 Neutral Fuels	03 2592 2001

CHOREN Industries



Decentralized Hydrogen from Biomass for the Transport Sector

(ELECTRO-FARMING™ Approach)



Global Energy Contents of Potential Crops, forest and Animal Waste Residues (PJ)

Region	*Crops*	*Forest*	*Animal*	*Total*
D C	21,510	16,671	13,328	51,509
I C	16,528	18,802	6,295	41,626
World	**38,038**	**35,473**	**19,623**	**93,135**

Projection of Global Land Availability and Technical Energy Potential from Energy Crops Grown by 2050

Population, billion	8.296
Total land with crop potential, Gha	2.495
Cultivated land in 1990, Gha	0.897
Available area for biomass 2050	1.280
Maximum additional biomass, EJ*year	396
Total biomass energy, including 45 EJ*year of current tradtional biomass, EJ*year	**441**

Energy Plant Species

Global Availability

- Cordgrass (*Spartina spp.)*
- Fibre sorghum *(Sorghum bicolor)*
- Giant knotweed (*Polygonum sachalinensis)*
- Hemp (*Cannabis sativa)*
- Kenaf (*Hibiscus cannabinus)*
- Linseed (*Linum usitatissimum)*
- Miscanthus *(Miscanthus x giganteus)*
- Poplar *(Populus spp.)*
- Rape *(Brassica napus)*
- Reed Canary Grass (Phalaris arundinacea.*)*
- Rosin weed *(Silphium perfoliatum)*
- Safflower (*Carthamus tinctorius)*
- Soy bean (*Glycine max)*
- Sugar beet (*Beta vulgaris)*
- Sunflower (*Helianthus annuus)*
- Switchgrass *(Panicum virgatum)*
- Topinambur *(Helianthus tuberosus)*
- Willow *(Salix spp.)*

	Representative Energy Plant Species for different climate regions - Temperate Climate -	Pflanzenbau FAL/El Ba 2000

- Argan tree (*Argania spinosa)*
- Broom (Ginestra) *(Spartium junceum)*
- Cardoon (*Cynara cardunculus)*
- Date palm (*Phoenix dactylifera)*
- Eucalyptus (*Eucalyptus spp.)*
- Giant reed (*Arundo donax)*
- Groundnut *(Arachis hypogaea)*
- Jojoba *(Simmondsia chinensis)*
- Olive (Olea europaea.*)*
- Poplar *(Populus spp.)*
- Rape (*Brassica napus)*
- Safflower (*Carthamus tinctorius)*
- Salicornia (*Salicornia bigelovii)*
- Sesbania (*Sesbania spp.)*
- Soybean *(Glycine max)*
- Sweet sorghum *(Sorghum bicolor)*

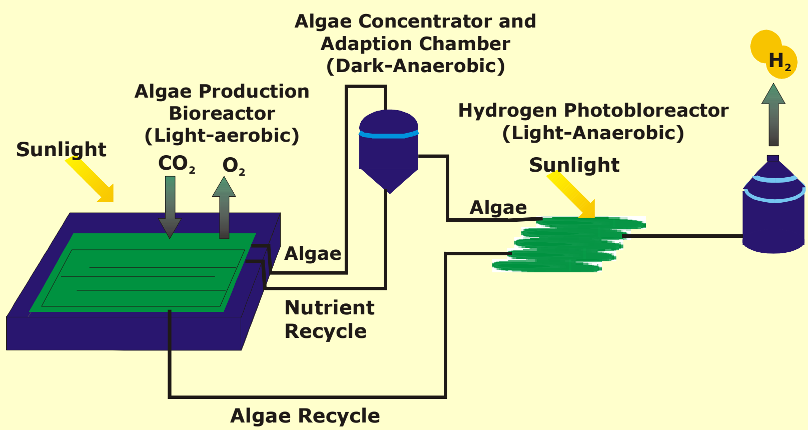
	Representative Energy Plant Species for different climate regions - Aride and Semiaride Climate -	Pflanzenbau FAL/El Ba 2000

- Aleman Grass (*Echinochloa polystachya)*
- Babassu palm *(Orbignya oleifera)*
- Bamboo (*Bambusa spp.)*
- Banana (*Musa x paradisiaca)*
- Black locust (*Robinia pseudoacacia)*
- Brown beetle gras (*Leptochloa fusca)*
- Cassava *(Manihot esculenta)*
- Castor oil plant *(Ricinus communis)*
- Coconut palm (*Cocos nucifera)*
- Eucalyptus *(Eucalyptus spp.)*
- Jatropha (*Jatropha curcas.)*
- Jute *(Crocorus spp.)*
- Leucaena (*Leucaena leucoceohala)*
- Neem tree (*Azadirachta indica)*
- Oil palm (*Elaeis guineensis)*
- Papaya (*Carica papaya.)*
- Rubber tree *(Acacia senegal)*
- Sisal *(Agave sisalana)*
- Sorghum *(Sorghum bicolor)*
- Soybean *(Glycine max)*
- *Sugar cane (Saccharum officinarum)*

	Representative Energy Plant Species for different climate regions - Tropical and Subtropical Climate -	Pflanzenbau FAL/El Ba 2000

Biodiversity is an Economical Necessity for Cultivated Forests

Microalgae conceptual two-stage biphotosynthesis process

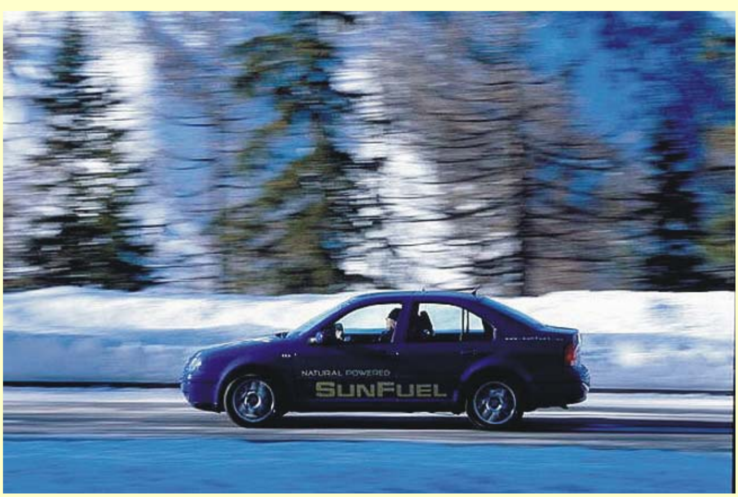


Fuel Yields from Biomass

Biomass Yield ($t\ ha^{-1}.\ y^{-1}.\ kg^{-1}$)	Energy content ($MJ\ .\ kg^{-1}$)	eta Conversion Efficiency	Fuel Yield ($t.\ ha^{-1}.\ y^{-1}$)	Fuel Yield ($l.\ ha^{-1}.\ y^{-1}$)
10	17,5	0,48	1,9	2448 (3000)
20	17,5	0,48	3,8	4895 (6000)
30	17,5	0,48	5,7	7343 (9000)

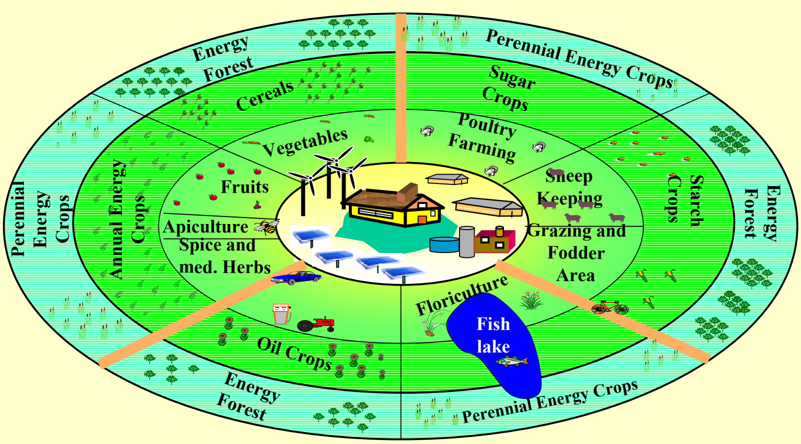
SunFuel

VW Bora HY.POWER



Simplon – Pass (Italy)

VW Lupo3L



IFEED	**Basic Elements of the Integrated Energy Farm (IEF)** **(Farm dwelling, Storage/Garage/Warehouse, Animal stables, Biofuel Heat & PowerStation, Wind power and Solar energy generation)**	FAO 2000 FAL

-Oilfields of the 21st century-

Conclusion

Of all Options, Biomass Represents the Largest and Most Sustainable Alternative to Substitute Fossil Transport Fuels as „Win–Win“ Strategy.

Thank you for your attention !

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