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Innovative Fuels and Biomass Resources

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Future alternative fuels should offer the possibilities to be used as the current fuels within the existing infrastructure, to contribute to the reduction of greenhouse gases, to promote the development of new technologies of the recent combustion systems and energy generation (i.e. fuel cells), to be affordable, sustainable and they should be renewable. Moreover, they have to ensure a safe supply within the regional and global markets.

Biomass can be considered as the best option and it has the largest potential, which meets these requirements and could insure fuel supply in the future. Plant oils, bio diesel, biogas and ethanol have been successfully introduced and are already in use. Innovative synthetic fuels are related to aspects and the new developments in conversion technologies of lignocellulosic to fuels: Gasification, pyrolysis and upgrading to gasoline, diesel and hydrogen, methanol, DME as well as the possibilities of their generation from biomass.

Fuels derived from biomass are not only potentially renewable, but they are also sufficiently similar in origin to fossil fuels in order to provide direct substitution opportunities. They can be converted into a wide variety of energy carriers (biogas, biodiesel, ethanol, methanol, DME, diesel, gasoline, hydrogen) as of recent fossil fuels through conversion technologies, and thus have the potential to be significant new sources of energy for the 21st century (Fig. 1).

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. Data related to global conversion of solar energy to biomass are summarised in table 1 and the possible contribution of biomass in future global energy supply is given in table 2.

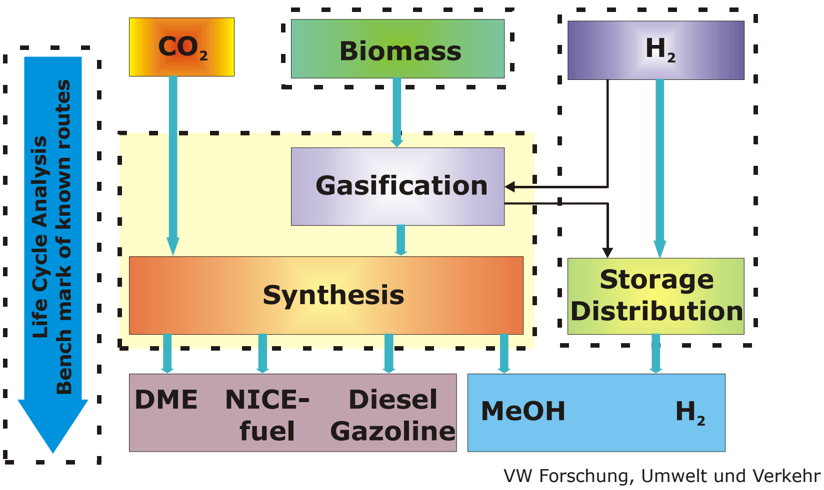

Figure 1: Pathways to Renewable Fuels (from plant to tank)

1000 kWh is 3.6 GJ and 1 ha is 10 000 m², so the total annual energy is	36 000 GJ
One third of this delivered during the growing period	12 000 GJ
20% of which reaches the growing leaves	2 400 GJ
After a further loss of about 20% by reflection	2 000 GJ
50% of this is photosynthetically active radiation	1 000 GJ
30% of which is converted into stored energy	300 GJ
But 40% is consumed in sustaining the plant, leaving	180 GJ
Corresponds to	10 t ha^{-1} y^{-1} GJ

Table 1: Conversion of Solar Energy (Annual Energy Delivered by Solar Radiation is 1000 kWh m^{-2} y^{-1}. ha^{-1})

Scenario	**Year of Scenario**		
	2025	2050	2100
IEA (1998)	60*	--	--
IIASA/WEC (1998)	82**59***	153** 97***	316** 245***
Shell (1996)	85	200-220	--
IPCC (1996)	72	280	320
Greenpeace (1993)	114	181	--
Johansson *et al* (1993)	145	206	--
WEC (1993)	59	94-157	132-215
Dessus *et al* (1992)	135	--	--
Lashof and Tirpak (1991)	130	215	--

* *2020 (Total primary energy supply)*
** *Scenario A3 (High growth – biomass and nuclear)*
*** *Scenario C1 (ecologically driven - large renewables, no nuclear)* **Source: Hall (1999)**

Table 2: The role of modernized biomass in the future global energy use (Present biomass energy use is about 55 EJ/year)

Biomass can be considered as a source for carbon and hydrogen (table 3). The possible outcome of oil from biomass depends on the productivity of energy plants and up to 9000 l oil through modern conversion technologies from one hectare could be achieved (table 4).

Fuel	*Ratio of atoms*			*% by weight*		
	C	H	O	C	H	O
Coal	1	1	<0.1	85	6	9
Oil	1	2	0	85	15	0
Methane	1	4	0	75	25	0
Wood	1	1.5	0.7	49	6	45

Table 3: Proportions of carbon, hydrogen and oxygen in fuels

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)*

Table 4: Fuel yields from biomass

More than 100 plant species have been identified for different region of the world to serve as biomass sources for biofuels. A summery of energy plant species which could be grown under various climatic conditions have been documented in the tables 5-7.

Table 5: Representative energy plant species for different climate (temperate climate)

- 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.)*

Table 6: Representative energy plant species for different climate (aride and semiaride climate)

- 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)*

Table 7: Representative energy plant species for different climate (aride and semiaride climate)

- 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)*

Figure 2 shows the energy plantation of the Federal Agricultural Research Centre (FAL) which represents the "Oilfields of the 21st century.

Figure 2: A VW car fuelled with "SunFuel" from biomass on the energy plantation of FAL.

Summery and Perspectives

- Annual primary biomass production: 220 billion 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 is efficiency 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 biomass producing areas (> 200 millions ha).
- Microalgae have the potential to achieve a greater level of photosynthetic efficiency 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 photosynthetic 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 accelerating 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.

Conclusion

Of all options, biomass represents the largest and most sustainable alternative to substitute fossil transport fuels as "Win-Win" strategy.

Reference

El Bassam, N. (1998) Energy plant species: Their use and impact on environment and development. James&James Science Publishers, UK.